Beddington Zero Energy Development

BEDZED

Total Energy Strategy
including Green Transport Plan

BioRegional Development Group, November 1999

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CONTENTS

Chapters 1 and 2 contain an overview of this report. Chapters 3 to 9 contain additional information on topics covered in the summary.

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1. INTRODUCTION

Beddington Zero (fossil) Energy Development (BedZED) is an energy efficient development comprising 78 homes, 1500m^2 of office space and a shop, café, healthy living centre and childcare facility. BedZED will be built on a disused sewage works in Hackbridge, London Borough of Sutton.

The BedZED design concept is driven by the desire for a net 'zero (fossil) energy development' i.e. one which will produce at least as much energy from renewable sources as it consumes. Only energy from renewable sources will be used to meet the energy needs of the development. BedZED will therefore be a carbon neutral development - resulting in no net addition of carbon dioxide to the atmosphere.

The buildings at BedZED would achieve a SAP rating (the government's Standard Assessment Procedure for Energy Rating of Dwellings (1998 Edition) BRECSU) equivalent to 150 and a 60% reduction in energy demand, including a 90% reduction in heat demand. Buildings will be constructed from thermally massive materials that store heat during warm conditions and release heat at cooler times. In addition, all buildings will be enclosed in a 300mm insulation jacket.

BedZED houses are arranged in south facing terraces to maximise heat gain from the sun, known as passive solar gain. Each terrace is backed by north facing offices, where minimal solar gain will reduce the tendency to overheat and the need for energy hungry air conditioning.

Due to the building construction, heat from the sun, and that generated by occupants and every day activities such as cooking is sufficient to heat BedZED homes to a comfortable temperature. The need for space heating, which accounts for a significant part of the energy demand in conventional buildings, is therefore reduced or actually eliminated.

BedZED homes and offices will be fitted with low energy lighting and energy efficient appliances to reduce electricity requirements.

BedZED will be powered by a small scale combined heat and power plant (CHP). In conventional energy generation, the heat that is produced as a byproduct of electricity generation is lost. With CHP, this heat can be harnessed and put to use. At BedZED, the heat from the CHP will provide hot water, which will be distributed around the site via a district heating system of super-insulated pipes. Should residents or workers require a heating boost, each home or office has a domestic hot water tank that can double as a radiator.

The CHP plant at BedZED will be powered by offcuts from tree surgery waste which would otherwise go to landfill. Wood is a carbon neutral fuel because the CO_2 released when the wood is burned is equal to that absorbed by the tree as it grew.

To enable residents and workers to keep track of their heat and electricity use, meters will be mounted in each home and office kitchen.

Transport energy accounts for a large proportion of the energy consumption of any development. Therefore an energy efficient development must address transport energy demands. The BedZED project introduces the first legally binding Green Transport Plan as a condition of planning permission. The BedZED Green Transport Plan aims to reduce private fossil fuel mileage by 50%. This will be achieved through a number of initiatives including a car pool and the promotion of electric vehicles. A grant from the EU 5th Framework fund has been secured to install a 777m^2 photovoltaic solar array which will generate enough energy to power 40 electric vehicles.

Embodied energy is a measure of the energy required to manufacture a product. A product that requires large amounts of energy to obtain and process the necessary raw materials or a product that is transported long distances during processing or to market will have a high embodied energy. To reduce the embodied energy of BedZED, construction materials have been selected for their low embodied energy and sourced within a 35 mile radius of the site, where possible. The energy expended in transporting materials to the site is therefore minimised.

This report looks at BedZED in its 'living phase' – quantifying the energy costs of running the buildings and transport associated with the development. Quantifying the energy embodied in the construction of BedZED is outside the scope of this report.

This report can be read in two parts – chapters 1 and 2 contain an overview of the report and chapters 3 to 9 contain additional information on topics covered in this summary. The report quantifies the predicted energy consumption of the buildings (section 2.1.1, chapters 3, 4) and transport (sections 2.1.2, 2.1.3, chapters 5, 6) at BedZED and sets out how renewable energy sources will be harnessed to meet these energy demands (section 2.1.4). The site energy balance for BedZED is calculated in section 2.1.5. The opportunities for buying - at peak times - and selling - at times of low consumption - energy to a green tariff account are described in section 2.2.

Section 2.3 and chapter 7 examine consumer perceptions of energy efficient housing and transport and section 2.4 and chapters 8 and 9 quantify the cost savings associated with an energy efficient BedZED lifestyle.

Lastly, recommendations are made on reviewing central and local government policy to encourage future energy efficient developments (section 2.5).

The UK government is committed to a 20% reduction in 1990 CO_2 emission levels by 2010. The UK government currently expects to surpass this target, largely due to reductions in CO_2 emissions from power generation, manufacturing industry and commerce. In contrast, the latest edition of UK Energy and the Environment (Cambridge Econometrics, 1999) forecasts a 13% increase in household CO_2 emissions from 1990 levels by 2010 and a 1% rise in emissions from transport. The BedZED Total Energy Strategy demonstrates that, with an imaginative approach, the UK can successfully tackle CO_2 emissions from housing and transport.

In addition to its own targets, the government has committed itself to a legally binding 12.5 % reduction target for all greenhouse gases by 2008 – 12, agreed under the Kyoto Protocol to the Framework Convention on Climate Change, in December 1997.

The government consultation paper 'UK Climate Change Programme' (October 1998) details how the government considers the UK could meet the 20% reduction target. Measures outlined in the report include: 10% of electricity generation from renewables; efficiency gains in households and the service sector; and the increased use of CHP to meet final energy demand. The BedZED Total Energy Strategy incorporates all of these measures as part of a comprehensive approach to minimising CO_2 emissions and reliance on fossil fuels.

In order to reverse the trend for increasing CO_2 emissions from housing we need an imaginative reappraisal of the way our homes are built. BedZED demonstrates that comfortable, desirable, affordable, energy efficient buildings are the homes and workplaces of the future.

2. SUMMARY

2.1 Total Energy Balance

This chapter quantifies the predicted energy consumption of the buildings and transport at BedZED. It then sets out how renewable energy sources will be harnessed to meet these energy demands and calculates the site energy balance.

2.1.1 Building Energy Consumption

Chapter 3, Energy Analysis, predicts the electrical energy requirements of each house type at BedZED assuming the use of energy efficient appliances and low energy lighting. The electrical energy consumption of each house type is calculated for three scenarios. The worst case scenario is based on frequent use of appliances performing at the lower end of the energy efficiency spectrum. The best case scenario is based on less frequent use of the most energy efficient appliances on the market. These scenarios reflect the different lifestyles and energy consumption of, for instance, a couple with a child and a single person living in a similar 2 bedroom flat. Further information about the scenarios on which these calculations are based can be found in Chapter 3, Energy Analysis.

House type	*Worst case scenario (kWh / year)*	*Typical scenario (kWh / year)*	*Best case scenario (kWh / year)*
1 bedroom flat	4343	1723	989
2 bedroom flat	4867	2028	1189
3 bedroom maisonette	5863	2657	1663
3/4 bedroom town house	6137	2882	2449

Table 1: The predicted annual electrical energy requirements for each house type at BedZED

Chapter 4, Predicted Energy Use (Ove Arup and Partners, 1999) adds the electrical energy requirements for offices, community facilities and services such as streetlighting and hot water pumps. The electrical energy requirements of the offices and community facilities are based on DETR best practice figures for each building type (DETR, 1998). The predicted heat energy requirements across the site are also calculated.

	Heat energy (kWh / winter day) [1]	*Electrical energy (kWh / day)* [1]	*Total energy (kWh / winter day)* [1]
Residential	1270	723	1993
Offices	300	189	489
Community facilities	396	456	852
CHP	850	51	51
Other e.g. streetlighting	n/a	251	251
Total daily energy (kWh)	2816	1670	3585
Total annual energy (kWh)	**882,977** [2]	**640,028** [3]	**1,212,755** [4]

[1] Chapter 4, Predicted Energy Use, Ove Arup and Partners, 1999
[2] Adjusted to allow for reduced summer heating demands and 20% losses in distribution
[3] Adjusted to allow for 5% losses in distribution
[4] Adjusted to allow for reduced summer heating demands and distribution losses

Table 2: The predicted daily and annual heat and electrical energy requirements at BedZED

2.1.2 *Transport Energy Consumption*

Transport of people and goods consumes, typically, one third of a country's energy requirements (Wackernagel et al, 1993). The construction of transport infrastructure and vehicles and travel itself use huge amounts of resources in material, land, energy and time.

An energy efficient development must therefore address transport energy demands. A Green Transport Plan has been devised to reduce the energy consumption of travel by BedZED residents and workers.

It is predicted that transport energy consumption at BedZED will change over time as the composition of vehicles on site changes. Transport energy consumption will fall as:

- residents and workers reduce car use in favour of public transport, walking and cycling
- residents give up their car or forego the purchase of a first or second car to join the car pool

A shift from fossil fuel to electric vehicles will also reduce energy consumption.

Scenario	*Transport energy consumption (kWh / year)*	*% of total transport energy generated from on site renewable sources*
Equivalent conventional development	963,098	0
BedZED year 1	709,589	2
BedZED year 5	527,679	6
BedZED year 10	244,746	34

Table 3: The predicted transport energy consumption and percentage of total transport energy generated from on site renewables for BedZED and an equivalent conventional development

From table 3 it can be seen that annual transport energy consumption at BedZED in year 1 is predicted to be 75% of an equivalent conventional development. This figure is predicted to fall to 55% in year 5 and just 30% in year 10. By year 10, it is predicted that a third of the transport energy demand at BedZED will be met from on site renewables.

The reduction in transport energy consumption and shift to transport powered by renewable energy will be achieved by implementing the BedZED Green Transport Plan.
The Green Transport Plan target of reducing private, residential fossil fuel mileage by 50% compared to an equivalent conventional development is met in the scenario predicted for year 5.

2.1.3 *Green Transport Plan*

BedZED residents and workers will be offered a comprehensive package of transport options which will enable them to retain travel flexibility whilst reducing dependence on private, fossil fuel cars. These transport initiatives are brought together in a legally binding Green Transport Plan.

The Green Transport Plan sets a target of reducing BedZED residential fossil fuel car mileage by 50% compared to an equivalent conventional development.

The Green Transport Plan aims to reduce car use and car ownership at BedZED by:

i. Reducing the need to travel

- BedZED is a mixed use development, offering the opportunity for residents to live and work on site, therefore eliminating the need to commute to work.
- To reduce shopping related travel, residents will be encouraged to order shopping over the internet. Regular, co-ordinated deliveries of BedZED orders will reduce shopping delivery miles.
- BedZED incorporates a shop, café, childcare facility and healthy living centre reducing the need for residents and workers to travel off site for these facilities.

ii. Promoting public transport

- Information about local public transport services will be widely available.
- Discounted season tickets will be negotiated for residents and workers
- A minibus service to the nearest railway station will be offered at peak times
- Where there is sufficient demand, existing public transport services will be supplemented by Sutton Community Transport

iii. Offering alternatives to private car travel

- BedZED will encourage cycling by offering designated cycle storage for residents and workers, workspace showering facilities and an on-site cycle repair facility. The site will be linked into the existing cycle network.
- A car pool will be established on site, offering the opportunity to hire a range of vehicles by the hour. Residents will be encouraged to give up their cars and use the car pool.
- Residents who are keen to retain the use of a private car will be encouraged to change to an electric vehicle.

2.1.4 *On Site Renewable Energy Production*

Electricity and heat at BedZED will be generated by a wood-fired combined heat and power plant (CHP) using gasification. The wood gas fires a spark ignition engine which runs a generator to produce electricity for lighting and running appliances. Heat from the exhaust and from the engine radiator is tapped and used to provide hot water and top up heating.

Each house at BedZED is fronted by a south-facing conservatory to maximise passive solar gain. Heat from the sun makes a substantial contribution towards heating BedZED houses to a comfortable temperature, therefore reducing the need for central heating.

Photovoltaic solar panels will be built into the roof fabric of the south-facing conservatories. The electricity generated from the PV panels will be sufficient to power 40 electric vehicles.

Energy source	*kWh / year* [1]
CHP electricity output	682,550
CHP heat output	949,365
Passive solar	134,116
PV solar	97,000
Total	**1,863,031**

[1] Chapter 4, Predicted Energy Use, Ove Arup and Partners, 1999

Table 4: The annual energy production from on site renewable sources at BedZED

From table 4 it can be seen that passive solar gain contributes the equivalent of 134,116kWh per year towards heating the buildings at BedZED. As all of this energy is effectively 'consumed' for heating, the passive solar energy balance is zero. Passive solar is therefore not included in site energy balance calculations.

2.1.5 *Site Energy Balance*

The BedZED design concept is driven by the desire for a zero (fossil) energy development i.e. one which will produce at least as much energy from renewable resources as it consumes. In addition, BedZED is designed to be a carbon neutral development, resulting in no net addition of CO_2 to the atmosphere.

2.1.5.1 Building Energy Balance

	Energy production (kWh / year) [1]	*Energy consumption (kWh / year)*	*Building energy balance (kWh / year)*
Electricity	682,550	640,028	+ 42,522
Heat energy	949,365	882,977	+ 66,388

[1] Chapter 4, Predicted Energy Use, Ove Arup and Partners, 1999

Table 5: Predicted building energy production and consumption at BedZED

From table 5 it can be seen that there is a predicted excess of electrical and heat energy generation over consumption. Excess heat energy generated by the CHP is primarily used for woodchip drying (so improving the gasification efficiency) and the remainder will be lost to the atmosphere. Excess electricity will be exported to the grid, on a green tariff account. Many regional electricity companies now offer a green tariff where energy generated from renewable sources is bought from suppliers and sold to customers at a premium rate.

2.1.5.2 Transport Energy Balance

Scenario	*PV solar electricity production* (kWh / year) [1]	*Electricity consumption (kWh / year)*	*Electricity balance (kWh / year)*
Year 1	97,000	14,548	+ 82,452
Year 5	97,000	33,929	+ 63,071
Year 10	97,000	83,229	+ 13,771

[1] Chapter 4, Predicted Energy Use, Ove Arup and Partners, 1999

Table 6: Predicted transport electricity production and consumption at BedZED for years 1, 5 and 10

From table 6 it can be seen that in each predicted scenario there is an excess of electricity generation over electricity consumption. This positive electricity balance will be exported to the grid on a green tariff.

Scenario	*Fossil fuel energy consumption (kWh / year)*
Year 1	695,041
Year 5	493,750
Year 10	161,517

Table 7: Predicted fossil fuel transport consumption at BedZED for years 1, 5 and 10

From table 7 it can be seen that the use of fossil fuel vehicles at BedZED represents an energy deficit in each of the predicted scenarios.

2.1.5.3 Site energy balance

Scenario	*Site renewable energy balance (kWh / year)*	*Site fossil fuel energy balance (kWh / year)*
Year 1	+ 124,974	- 695,041
Year 5	+ 105,593	- 493,750
Year 10	+ 56,293	- 161,517

Table 8: The predicted site energy balance for BedZED for years 1, 5 and 10.

Table 8 shows a reduction in the predicted site renewable energy balance from year 1 to year 10 as an increasing proportion of electricity generated by PV solar is used to power electric vehicles. It is predicted that the negative fossil fuel energy balance will decrease from year 1 to year 10 as the number of petrol and diesel vehicles on site falls.

The use of fossil fuel vehicles on site and in servicing the site cannot be met directly by on site renewable energy generation, hence the BedZED Green Transport Plan focuses on the minimisation of fossil fuel vehicle use.

Excess electricity generated at BedZED by the CHP plant and PV panels will be exported to the grid. This will reduce the amount of electricity that needs to be generated from fossil fuel sources elsewhere, resulting in reduced CO_2 emissions from electricity generation. These savings in CO_2 emissions can be offset against CO_2 emissions from fossil fuel vehicles at BedZED.

Year	*CO_2 emissions from fossil fuel vehicles (tonnes)* [5]	*CO_2 savings from excess electricity generation (tonnes)* [6]	*Net CO_2 emissions from transport at BedZED (tonnes)*
1	202	62	140
5	143	53	90
10	47	28	19

[5] For each kWh energy used by a fossil fuel vehicle, 0.29kg CO_2 is emitted to the atmosphere.
[6] For each kWh electricity used, 0.5kg CO_2 is emitted to the atmosphere (DETR, 1998).

Table 9: Predicted net CO_2 emissions resulting from transport at BedZED in years 1, 5 and 10.

Transport associated with BedZED will not be carbon neutral until all private and car pool vehicles, all vehicles that service the site and all public transport used by site residents are powered from carbon neutral sources. However, due to the measures in the Green Transport Plan, the predicted year 10 CO_2 emissions from BedZED transport will be reduced to just 4% of the CO_2 emissions resulting from an equivalent conventional development.

The net CO_2 emissions from transport at BedZED could be offset through the Climate Care scheme run by the Carbon Storage Trust. Climate Care offsets greenhouse gases by investing in presently unviable or otherwise blocked investments in energy efficiency, renewable energy and forest restoration, for £5.45 per tonne of CO_2.

The energy demands of BedZED transport cannot be carbon neutral in terms of being wholly met from on site renewables. However, if minimal CO_2 emissions are offset through the Climate Care scheme there will be no net addition of CO_2 to the atmosphere as a result of transport at BedZED.

2.1.6 Conclusions

2.1.6.1 Buildings

The BedZED CHP will generate sufficient heat for space heating, hot water and drying the CHP woodchip fuel. The small excess in generation is lost to the atmosphere. In addition, the CHP will generate sufficient electricity to meet the building energy demand of the site and export a predicted 42,522kWh per annum to the grid.

The energy demand of the buildings at BedZED will therefore be met wholly from renewable energy sources, within the site's footprint.

2.1.6.2 Transport

The PV panels will generate enough electricity to power 40 cars and export a predicted 13,771kWh per annum to the grid (year 10 scenario).

As long as private and car pool vehicles, vehicles that service the site and public transport used by site residents are powered by fossil fuels there will be a negative fossil fuel energy balance at BedZED. However, it is predicted that by year 10, the negative fossil fuel energy balance will be reduced to 161,517kWh per year, just one sixth of the energy consumed by petrol and diesel vehicles in an equivalent conventional development.

2.2 GREEN TARIFF ELECTRICITY

It is not economic to size the BedZED CHP unit to meet the peak electricity demand of the development. Therefore, a connection to the national grid will enable energy to be drawn in on a green tariff during times of peak demand and surplus energy to be sold to the grid at times when supply exceeds site demand.

Since the deregulation of the energy companies, the number of regional energy companies offering green tariffs has increased rapidly. Green tariff energy is energy generated from renewable sources which is bought from suppliers and sold to customers at a premium rate.

All of the green tariffs currently available involve payment of a premium. Green tariffs are either 'renewable tariffs', where for each unit of electricity used by the customer on this scheme, the supplier will buy a unit of electricity from a renewable source; or 'eco funds' where the additional customer premium is invested in new renewable energy projects.

	Green tariff	*Quarterly increase in average bill*	*Other information*
Centrica	Planned		
Eastern	EcoPower / EcoPower Plus (Eco fund)	£3.45 and £7.04 respectively	Eastern Energy will match the money raised, pound for pound, up to a maximum of £1 million over 2 years
East Midlands Electricity	Planned		
London Electricity	Planned		
Manweb	Green Energy (Eco fund)	£3.51	Funds will be used to purchase new green electricity at the market rate or to finance new renewable projects. Companies involved will match, at least pound for pound, the money raised.
Northern Ireland	Eco Energy (Eco fund)	£1.04, £5.20, or £10.40 [7]	Also offers discount vouchers for purchase of eco-friendly products
Northern	Planning to launch in mid '99 (Renewable tariff / eco fund)	£2.88	Funds will be used to support the cost of new renewable generation, or carbon offset projects such as reforestation. Customers can choose how their surcharge is used. The tariff will also offer an introductory energy efficiency package (e.g. low energy light bulbs or discounted insulation)
Norweb	No domestic green tariff planned		
Renewable Energy Co.	Eco-tricity (available end 1999)		
Scottish Hydro Electricity	Acorn (Renewable tariff)	£2.73	
Scottish Power	Green Energy (Renewable tariff)	£3.81	Funds will be used to purchase new green electricity at the market rate or to help finance new renewable projects. Companies involved will match, at least pound for pound, the money raised.
Seeboard	Planned for mid-2000 (Eco fund)		
Southern Electricity	Acorn (Renewable tariff)	£2.73	
SWEB	Green Electron (Renewable tariff)	£7.30	
Unit[e]	Renewable tariff		
Yorkshire	Green Electricity (Renewable tariff)	£4.21	Free low-energy light bulb given to customers signing up to the tariff.

[7] Customers can choose to have 10%, 50% or 100% of their energy supplied from Eco Energy

Table 10: The current range of green tariffs available to domestic consumers (Friends of the Earth, October 1999)

2.3 CONSUMER BEHAVIOUR TOWARDS ENERGY EFFICIENT HOUSING AND TRANSPORT

Questionnaires examining attitudes towards environmentally friendly housing were distributed to a random sample of 500 addresses within the M25 and inserted in 500 copies of the magazine Permaculture.

189 responses to the questionnaire were received, 49 responses from households within the M25 (M25 sample) and 140 responses from readers of Permaculture magazine (Permaculture sample).

The questionnaire included a number of questions relating to the BedZED energy strategy, the responses to which were analysed for this report.

Respondents were asked to rate the importance of various features of environmentally friendly houses. Energy efficiency and the use of renewable energy were identified as the most popular features of an environmentally friendly house by both samples.

Respondents were asked how likely they were to consider getting rid of one or more of their cars if a car pooling scheme was available. 64% of the Permaculture sample and 35% of the M25 sample thought it extremely or quite likely that they would take up this option. In the M25 sample, most of those who were unlikely to take advantage of a car pooling scheme (41%) felt very strongly that they would not give up their car.

Even amongst the M25 sample, who are likely to be less environmentally motivated than the Permaculture sample, a third of respondents were willing to give up a private car in favour of a pool car. This suggests that the Green Transport Plan target of 8% of BedZED residents giving up a private car in year 1 is achievable.

Further information on consumer behaviour towards energy efficient housing and transport can be found in chapter 7.

2.4 REDUCED RUNNING COSTS FOR ENERGY EFFICIENT HOUSING AND TRANSPORT

Energy efficient housing and transport offer significant benefits to the environment in terms of reduced CO_2 emissions. In addition, BedZED residents will benefit from lower household bills and residents who give up a private car to join the car pool will be financially better off. Based on the experience of members of their 'City Car Club' car pool in Edinburgh, Budget Car and Van Rental suggest that a member with an annual mileage of 11,000 - 13,000km could save up to £1,500 per year on their motoring costs.

A household living in a 3 bedroom BedZED maisonette could save up to £240 per year, £134 on electricity and £106 on space and water heating, compared to a household living in an equivalent house built to 1995 building regulations. These savings are despite the fact that BedZED households will pay a premium rate for their green electricity.

A BedZED resident giving up a private car in favour of a pool car could run a well serviced bike and take 5 local bus or train trips per week, 2 £5 minicab journeys per week and 1 day car hire per week from a local firm for the same price as running a private car. For shorter journeys, hiring a car pool by the hour will be cheaper than hiring a car by the day, offering residents greater flexibility at a lower price.

This calculation does not take into account the commuting costs for BedZED residents who work in London. It is assumed that residents will commute into London by train regardless of whether they own a car or not, as the nearby Hackbridge and Mitcham Junction stations offer regular, direct trains into London.

Further information on the potential annual savings on energy bills and car running costs for BedZED households can be found in chapters 8 and 9 respectively.

2.5 ENCOURAGING ENERGY EFFICIENT DEVELOPMENTS: RECOMMENDATIONS FOR POLICY MAKERS

There are many opportunities for local and central government to reform and develop policies to encourage future energy efficient developments.

2.5.1 *Planning policy guidance*

The Unitary Development Plan (UDP) of a sympathetic local authority can include policies that offer an open door to green developers. However, local authorities have to wait for such developers to approach them rather than having the power to influence more conventional developers.

Local authority planning policy guidance, such as PPG1 which sets out national sustainable development guidelines, is issued from central government. PPG1 currently focuses primarily on sustainable development in relation to land use, with little guidance on achieving sustainable development in terms of building design.

It is recommended that PPG1 is extended to give a more comprehensive coverage of issues relevant to green housing developments. In addition, specific, enforceable policies would enable local authorities to impose targets for greener buildings on developers.

There are some policy areas, such as car parking, where local authorities have the power to set their own standards. As in the case of BedZED, where it can be demonstrated that parking needs will be lower than usual, the local authority can reduce the number of parking spaces required.

In cases where local authorities have greater flexibility, the opportunity should be taken to develop policies favourable to sustainable housing developments.

Local authorities have some scope to ring fence revenue for specific uses. This enables expenditure on sustainable development without increasing spending. For instance, income from car parking charges can be used to subsidise public transport. Local authorities should be encouraged to use these powers creatively to encourage sustainable development.

2.5.2 Environmental Budgeting

Local authorities have traditionally been obliged to sell land to the highest bidder. However, the land for BedZED was sold to Peabody Trust by London Borough of Sutton at a lower cash price than that of the highest bidder for the site. This was possible because a study was commissioned to attach an economic value to the environmental benefits of BedZED over a conventional development. Once the environmental benefits of BedZED were valued in monetary terms, the Peabody bid was in line with the rival bid. As a result, a local authority was able to take the environmental benefits of a development into account for the first time. Certain benefits, such as reduced CO_2 emissions were relatively easy to price but other benefits, such as reductions in water consumption and car use, were impossible to value economically.

In December 1998 local authorities were granted a general disposal consent enabling them to accept tenders up to 20% (land value £1 million or less) or 10% (in the case of higher values) lower than the land value. Local authorities are therefore no longer required to maximise income from land sales, but can consider lower bids within a certain range. It is recommended that this change be brought to the attention of local authorities along with information regarding the opportunities for using this as a mechanism for encouraging green housing developments. Local authority attention should also be drawn to existing government guidance on attaching monetary values to environmental benefits, published in 'The Green Book – Appraisal and Evaluation in Central Government'. This information could be incorporated into the appropriate planning policy guidelines.

2.5.3 Building Regulations

Approved Document Part L of the Building Regulations which deals with energy efficiency is currently under review. It is recommended that improved standards for U-values, air tightness and ventilation are set as a result of this review process. The introduction of guidance on the use of renewable energy to meet building energy demands is also recommended.

2.5.4 Climate Change Levy

The Climate Change Levy on business use of energy will be introduced from April 2001. The government aims to achieve savings of 1.5 million tonnes of CO_2 per year by 2010 via this levy. The cost of the levy to business will be offset by a 0.5% cut in the rate of employer's national insurance contributions. Energy intensive users will be offered a reduced rate of levy in return for signing a negotiated agreement that sets targets for reducing energy use.

The levy does not apply to energy generated from renewable sources or CHP. In addition, £150 million of the revenue from the levy will be invested in renewables. The Climate Change Levy begins to tip the balance in favour of renewables and will send a clear message to business that energy is now a tax target. This should add weight to energy efficiency measures when businesses are assessing energy options.

2.5.5 VAT on energy saving products

In the November 1998 budget, the government reduced the VAT rating on energy efficiency products used in government sponsored projects from 17.5% to 5% in line with the VAT rating on energy itself. However, energy efficient products used in government sponsored projects account for only a small percentage of all energy efficient products sold. It is therefore recommended that all energy efficiency products e.g. insulation, low energy light bulbs, triple glazing are VAT rated at 5% to reduce the cost disparity between conserving and using energy.

2.5.6 Generation of renewables

It is recommended that the UK government translates the UK national target for energy generation from renewables into individual targets for energy generating companies.

A similar Dutch scheme has encouraged energy generating companies to identify new, cost effective ways of generating from renewables. In one initiative, residents are being offered free installation of PV panels and a 2 way electricity meter so that electricity generated from their roof offsets the electricity they use.

3. ENERGY ANALYSIS

CONTENTS

1. SUMMARY

The Sainsbury Family Charitable Trusts granted funding to BioRegional Development Group to carry out a total energy analysis of ZED. The analysis will quantify the energy demands at ZED, including transport, and the energy that can be supplied from biomass and solar sources on site. The study will calculate the net site energy balance and identify renewable sources to make any deficit.

This first report summarises typical energy demands of domestic houses. It then goes on to predict the electrical energy consumption of ZED residents on the basis that energy efficient appliances will be installed throughout the development. The report presents existing data on energy consumption in offices and lastly it summarises the current situation with respect to trading "green" electricity (i.e. electricity from renewable sources).

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Total energy consumption in typical domestic houses is between 150 and 288 kWh per square metre floor area per annum (kWh / m^2 pa). This compares with a predicted total energy consumption of 75 kWh / m^2 pa at ZED. The difference is accounted for mainly by eliminating the space heating demand. There is also a predicted 10% reduction in electrical demand due to energy efficient electrical appliances and some reduction in water heating demand due to well insulated cylinders and short hot water pipework lengths.

Total energy consumption in a typical household is made up of approximately 50-60% space heating, 20-30% water heating, 5% cooking and 15% electrical appliances.

Lighting accounts for 17% of typical household electrical consumption, but by using low energy compact fluorescent light bulbs (CFL), the household demand can be reduced from an average of 750 kWh pa to 300 kWh pa. Installation of pin-based light fittings at ZED would ensure the use of CFL's in fixed lights but not in portable lamps that account for some 20% of the lighting energy demand.

Of all the household electrical appliances, cold appliances i.e. fridges and freezers are typically the biggest energy consumers (24% of lights and appliances). Choice of energy efficient fridges and freezers can save 10-20% of their energy consumption. Frost free cold appliances increase energy consumption by 45% and are not recommended for ZED. Vacuum insulation panels in cold appliances are newly being introduced and claim to reduce energy consumption by 80%. These may be affordable by the time ZED residents move in.

Energy labels on appliances have been shown to be more than one class less efficient than that claimed on their label. Alternative sources of information such as Which? And Scottish Hydro Electric's database will be used to select appliances for ZED.

It is recommended that no tumble dryers are installed at ZED but water and energy efficient dishwashers are allowed for. Energy efficient TV's and VCR's are now available on the market. Optional energy efficient appliances will be available to residents at a bulk discount rate and residents will be encouraged and informed as to why they should choose energy efficient appliances. There could be conditions in the leasehold stating that newly purchased appliances be energy efficient.

***

Section 2.3 of this report predicts the electrical energy demand for the domestic components of ZED. For each unit type, various occupant family types are considered. Different appliance usage patterns are used to derive worst, typical and best case scenarios.

Tables and graphs show the predicted electrical demand for each appliance for each scenario and the total predicted electrical demand for each unit type for each scenario. The following summarises the latter:

1 bed flat	900 – 4,500 kWh pa	- typical 1,700 kWh pa
2 bed flat	900 – 5,900 kWh pa	- typical 1,900 kWh pa
3 bed maisonette	1,400 – 6,500 kWh pa	- typical 2,700 kWh pa
3/4 bed town house	1,400 – 6,700 kWh pa	- typical 2,800 kWh pa

The results of this section can be used to predict heat gains from electrical appliances.

2. DOMESTIC

2.1 Total Energy Consumption

This section briefly presents existing methods of assessing household energy efficiency. It then goes on to present existing data for the total energy consumption of conventional domestic dwellings in the UK, and compares with the estimates for ZED dwellings provided by Ove Arup & Partners Consulting Engineers.

2.1.1 Energy efficiency assessment methods

Due to rising awareness of the need for energy efficiency, assessment methods have been designed to rate the energy efficiency of domestic buildings. Two of the most commonly used are National Home Energy Rating (NHER) and Standard Assessment Procedure (SAP) ratings.

2.1.1.1 NHER

The assessment procedure for the NHER index is based on a Building Research Establishment Domestic Energy Model (BREDEM) computer program. The NHER index is a 1-10 non-linear scale. The higher the number the more energy efficient the building (NES, 1999).

The average British house has a rating of 3.5 (Boardman, 1998). Houses built to the 1990 Building Regulations have an index of between 6 and 7. The index score, however, does not give a quantitative measure of how much energy the building will use. This depends on many factors including the occupancy patterns that can affect the fuel used in identical houses by up to a ratio of 5:1. The NHER index is calculated primarily using fuel costs but is independent of building size and incorporates the heating systems and insulation levels in the building. The index aims to give the same values to houses with the same heating appliances, level of insulation and fuel conversion efficiency (NES, 1999).

Table 2.1 Fuel costs for the NHER (National Home Energy Rating) index associated with three typical house sizes. 40 m^2 represents a typical one-bedroom flat, 80 m^2 an average 3 bedroom house in the UK, and 120 m^2 a 4 bedroom detached house (Boardman, 1998).

Fuel costs for a given floor area (£/pa)			
NHER	**40 m^2**	**80 m^2**	**120 m^2**
0	1000	1800	2700
1	750	1325	1900
2	610	1050	1500
3	520	875	1225
4	460	750	1025
5	410	650	900
6	370	580	775
7	340	520	690
8	340	460	640
9	280	400	530
10	260	350	450

2.1.1.2 SAP

SAP ratings are based on annual energy costs for space and water heating. A standard occupancy pattern is assumed, which is derived from the floor area and a standard heating pattern. The rating is then normalised for floor area. The rating is on a scale from 1-100, the higher the number, the more energy efficient the house. As with the NHER index, SAP ratings depend on many things, including thermal insulation, efficiency and control of the heating system, ventilation characteristics, solar gain characteristics and the price of fuel. It is not affected by things which do not affect the fabric of the building, for example, the size, geographical location and occupancy lifestyles (Building Regulations Approved Document L).

These two rating indices show how energy efficiency has been measured and understood to date, but do not quantify the energy demand.

2.1.2 Total Domestic Energy Consumption

From a variety of sources it has been found that domestic houses can have a total energy consumption of between 150 and 288 kWh/m^2 pa (per annum) (Uglow, 1982; BRE, Shorrock, 1999; Jones, 1998; Uglow, 1981; DETR, 1998) with an average value of 227 kWh/m^2 pa. Figures 2.1 and 2.2 show total energy demand of domestic houses. Figure 2.1 is subdivided into different house types.

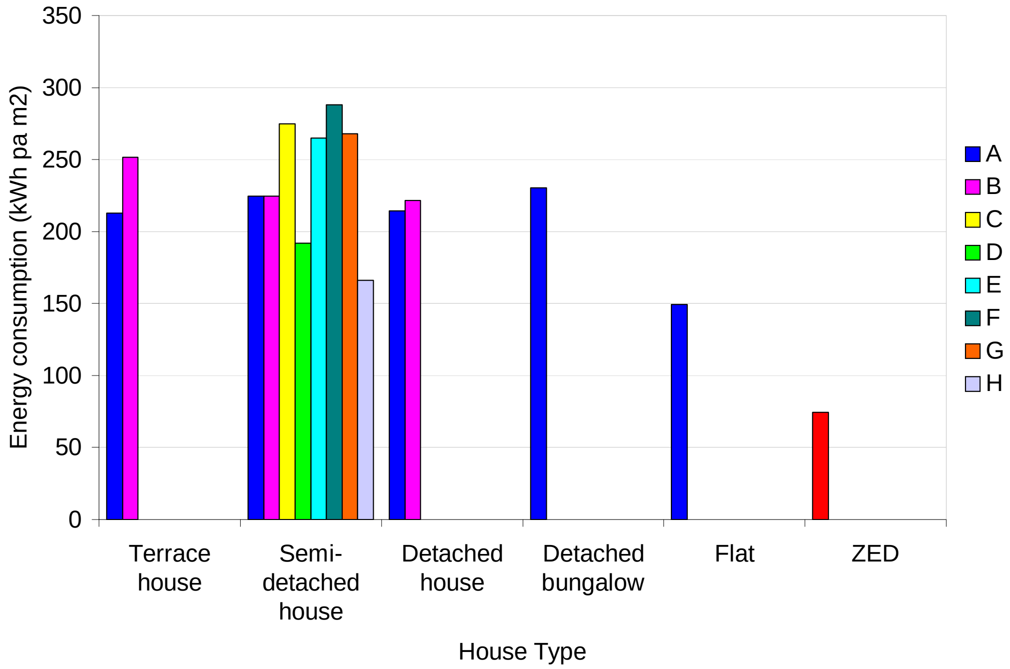

Figure 2.1 Total energy consumption of different domestic dwellings in the UK. The legend shows the source of the data.

A,	Uglow, 1982, a study of 42 Building Research Establishment (BRE) employees living in the Watford area.
B,	Jones, 1998, a comparative study of domestic heating costs in the South East of England.
C,	Shorrock, 1999, BRE typical value for an average UK semi-detached house with poor insulation.
D,	DETR, 1998, BRE value for a typical semi-detached house built to 1995 building regulations.
E,	Building Research Establishment Energy Assessment Method (BREEAM) 1993, houses built to the then current building regulations.
F	Uglow, 1981, average house with no insulation and single glazing.
G,	Uglow, 1981, average house with 50 mm of loft insulation and single glazing.
H,	Uglow, 1981, average house with 100 mm of loft insulation, cavity wall insulation, double glazing and heavy curtains.
ZED	Knight, 1999.

Appendices A and B show the energy calculations for this data.

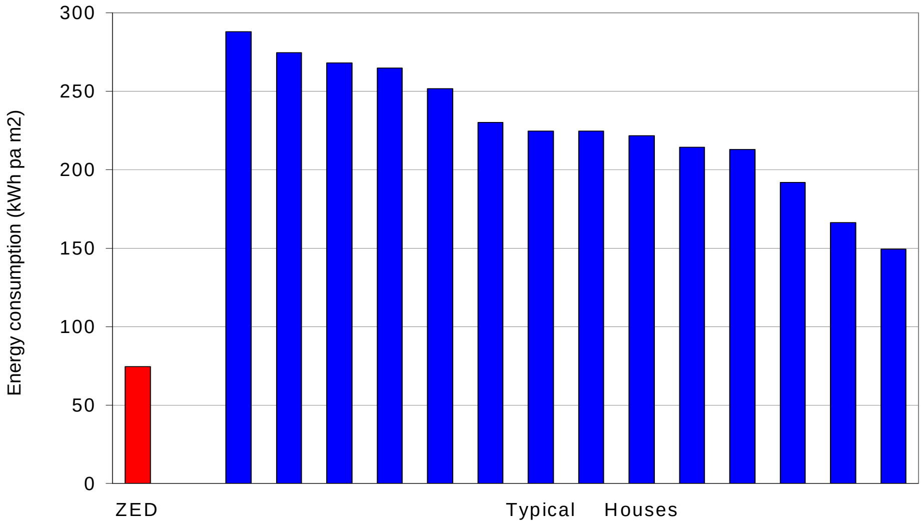

Figure 2.2 Energy consumption of a ZED house and conventional domestic houses in the UK (Uglow, 1981; Uglow, 1982; Jones, 1998; Knight, 1999; DETR, 1998; Shorrock, 1999). No distinction has been made between different types of houses.

2.2 Breakdown of Energy Consumption

Energy in the home is used for many different things. A typical household fuel bill can be approximately broken down into the amount spent on the different classes of energy consuming goods and facilities in the home (DoE, 1996).

Space heating	46.4 %
Water heating	17.6 %
Lights and appliances	25.5 %
Cooking	2.8 %
Standing charge	7.7 %

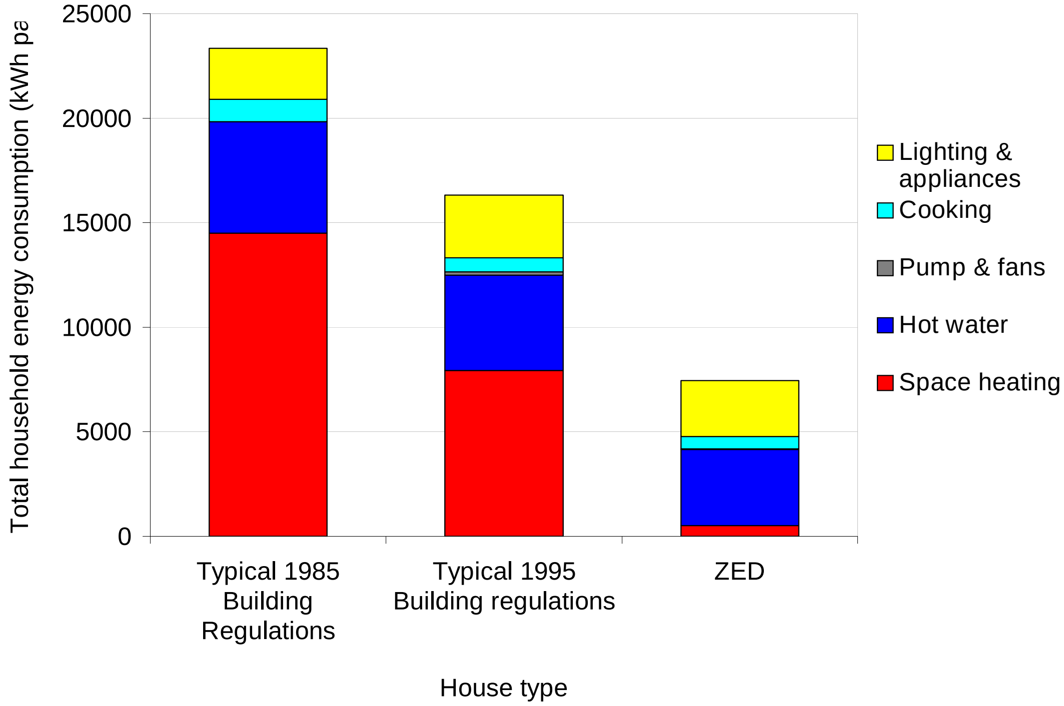

Figure 2.3 Breakdown of total household energy consumption (Shorrock, 1999; DETR 1998; Knight, 1999).

The greatest reduction in energy consumption from 1985 to 1995 (fig. 2.3 and table 2.3) is in the space heating requirement. This is due to increased levels of insulation and more efficient boilers. There are small reductions in water heating and cooking. Water heating will be accounted for by better insulating jackets on water tanks (Shorrock, 1999). The reduction in cooking is likely to be due to use of the microwave (DECADE, 1997a) and a reduction in the amount of home cooking.

A ZED house will only use approximately 7460 kWh pa (75 kWh/m^2 pa) (Twinn, 1998b and Knight, 1999), less than one third that of a 1985 conventional house. This reduction is mainly due to reducing the space heating demand to zero when fully occupied. The houses are designed to utilise between 600 and 1100 kWh pa of passive solar and incidental heat gains from people, cooking, lighting and appliances. An allowance of 500 kWh pa (5 kWh/m^2 pa) for space heating has been used as a contingency estimate to account for times when the properties are not fully occupied (Knight, 1999), see table 2.2.

Table 2.2 Annual energy consumption (kWh pa) for typical three bedroom semi-detached houses (Shorrock, 1999; BREEAM 1993; DETR, 1998; Knight, 1999).
* contingency space heating.

<table>
<tr><th></th><th>Typical 1985</th><th>Typical 1993</th><th>Typical 1995</th><th>ZED 1999</th></tr>
<tr><td>Space heating</td><td>14483</td><td rowspan="2">17760</td><td>7926</td><td>500*</td></tr>
<tr><td>Hot water</td><td>5350</td><td>4548</td><td>3650</td></tr>
<tr><td>Pump & fan</td><td></td><td></td><td>175</td><td>20</td></tr>
<tr><td>Cooking</td><td>1067</td><td rowspan="2">4750</td><td>656 gas</td><td>590</td></tr>
<tr><td>Lighting & appliances</td><td>2445</td><td>3000</td><td>2700</td></tr>
<tr><td>Total</td><td>23345</td><td>22510</td><td>16305</td><td>7460</td></tr>
</table>

Ove Arup estimate that ZED houses will use less energy for water heating than a typical 1995 house due to well insulated cylinders and short hot water pipework lengths. Due to passive wind driven ventilation and the absence of heating pumps, the energy demand for pumps and fans is also reduced. Cooking demands are estimated to be lower than for a typical 1995 due to occupant awareness of energy saving techniques.

The next four sections will look in detail at existing typical energy consumption data for different components of the total energy demand of domestic houses.

2.2.1 Water Heating

Anderson, 1978, found that the energy required for a water heater increases with the number of people in the household. The basic demand was 1000-1100 kWh pa, to which an extra 600-700 kWh per person was required. The following BRE data (see fig. 2.4) illustrates this finding.

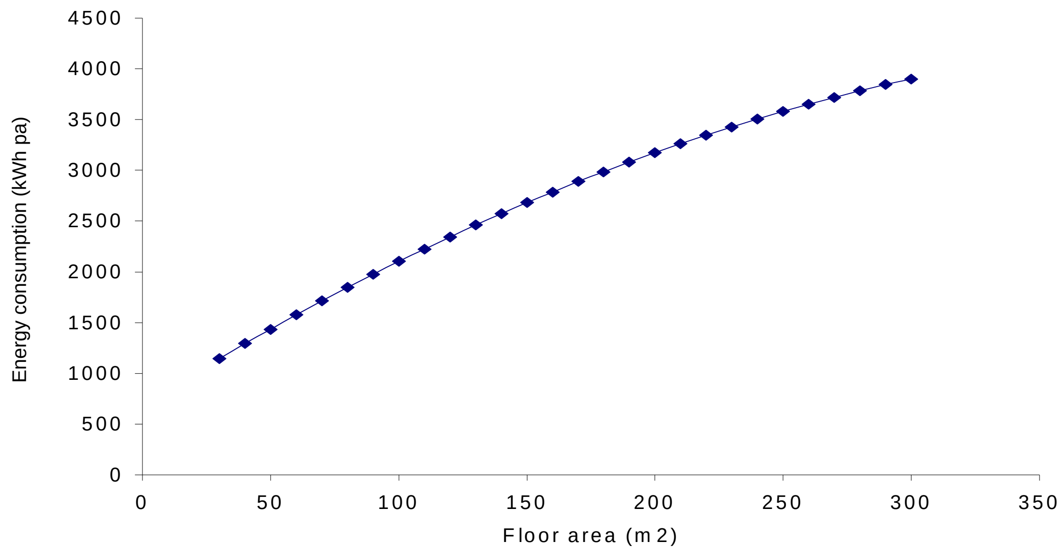

Figure 2.4 Energy consumption for heating water relative to the size of the dwelling (Building Regulations Approved Document L).

2.2.2 Cooking

The four major types of cooking appliance are the oven, hob, kettle and microwave. The other minor cooking appliances, including toasters, deep-fat fryers and food processors, etc. account for only 6 % of total cooking energy consumption (DECADE, 1997a).

Annual cooking consumption has reduced from 630 kWh in 1992 to 530 kWh in 1996 per household pa. This is due to declining household size and increasing microwave ownership (DECADE, 1997a). The annual energy demand for cooking has decreased even more dramatically since 1981, when it was 1190 kWh pa for electric cooking and 2380 kWh for gas (Uglow, 1981). It is possible that this is largely due to a reduction in home cooking and baking and an increased use of microwaves. A microwave displaces around 150-200 kWh pa of cooker energy consumption (DECADE, 1997a). If this trend continues, then the figures calculated for cooking energy consumption at ZED may also decrease.

The Billsavers 1 and 2 projects found the ratio of energy consumption between electric ovens and hobs to be between 50:50 and 60:40.

In the DECADE 2MtC report (1997a), it was found that single parents used almost twice the electricity for cooking as a single person, but only 75 % as much as couples with children. Surprisingly, they also found that two person households used twice as much electricity for cooking as a single person household.

2.2.3 Lighting

Total domestic lighting consumption in the 15 European Union (EU) member states represents 17 % of all residential electricity use (DELight, 1998). In a typical UK three-bedroom, uninsulated semi-detached house, the lighting consumes 10-15 % of total electrical demand (Energy Savings Trust, 1999). The Electricity Association, 1998, found this proportion to be 17 %. The average household lighting consumption in the EU ranges from 240 kWh pa to 920 kWh pa (DELight, 1998) but in the UK the average lighting consumption is approximately 750 kWh pa.

Large energy savings can be made from lighting. Only 30 % of households own a low energy compact fluorescent light bulb (CFL). CFLs use at least 60 % less electricity than normal incandescent bulbs.

Replacing the four most used bulbs in an average house would save approximately 200 kWh pa (Palmer, 1998).

The Electricity Association (1998) carried out a survey of the lighting and total electricity consumption in 100 homes in three regions of the UK; Southeast England, North East England and Central Scotland (see Table 2.3). Average annual lighting consumption was 758 kWh, of which nearly 20 % were portable plug in lamps. Lighting usage was highly seasonal, with the peak consumption month being December, when consumption was over 3 times that of June (lowest demand).

Table 2.3 Breakdown of lighting energy consumption in to main lights and lamps in the three monitored areas (Electricity Association, 1998).

		South of England	North of England	Central Scotland	Average
Annual consumption (kWh)	*Lighting Circuit*	606	683	467	594
	Main portable lights	79	179	263	164
	Total lighting	685	862	730	758
Lighting share of total electricity (%)		15.5	19.1	16.6	17
Maximum demand (kW)	*Lighting circuit*	0.39	0.41	0.24	0.3
	Main portable lights	0.04	0.08	0.13	0.08
	Total lighting	0.43	0.49	0.37	0.38

In the energy calculations for lighting at ZED, it has been assumed that 100 % of lights are fitted with CFL bulbs. If new occupants bring their own portable lamps with incandescent bulbs they should be encouraged to replace their incandescent bulbs with CFLs.

Pin-based fittings for CFLs would ensure the use of low energy light bulbs at ZED.
(DELight, 1998).

The Electricity Association study, 1998, found that there was a wide variation in average lighting consumption. Table 2.4 shows that lighting consumption was strongly associated with income, number of rooms and the number of people in the dwelling. Lifestyle differences appeared to have little effect on lighting usage, with the exception of those categorised in group F (striving, people in multi-ethnic and/ or low income areas), which used less electricity than others, particularly during the morning peak and over the evening. Households with 8 or more rooms have an average annual consumption of 80 % more than those with 5 rooms and tend to use more electricity for lighting over most winter weekdays.

Table 2.4 Trends found for differing lighting energy consumption (Electricity Association, 1998). Socio-economic categories are defined as:
A, 'Thriving' e.g. wealthy achievers, suburban areas
B & C, 'Expanding' and 'Rising' e.g. affluent executives, family areas
D, 'Settling', e.g. Skilled workers, home owning areas
E, 'Aspiring', e.g. new home owners, native communities
F, 'Striving', e.g. people in multi-ethnic, low income areas

		% of total	Average annual consumption	
		No. in sample	kWh	% of total load
Annual Income range	0 – 20,000	54	631	14.4
	Over 20,000	46	900	19.2
No. of main rooms	5 or less	25	527	14.9
	6	21	631	15.4
	7	25	732	17.7
	8 or more	29	951	17.9
Dwelling type	Detached	24	841	15.0
	Semi-detached	35	794	18.0
	Flat / maisonette	18	583	15.7
No. of persons	1	19	505	13.1
	2	21	552	16.8
	3	17	701	14.6
	4 or more	43	930	18.7
Socio-economic Category	A	30	769	15.2
	B&C	19	763	17.2
	D	20	757	19.0
	F	26	729	18.3
Low energy lighting	Installed	27	691	15.3
	None installed	73	749	17.3
Other appliances on lighting circuit	Customers with	12	497	11.5
	Customers without	88	781	17.4
Rooms always requiring artificial lighting	Customers with	16	754	15.5
	Customers without	84	725	16.9

The lighting demand of detached and semi-detached houses was greater than demand in flats and maisonettes.

Lighting demand in one or two person households shows a less pronounced evening peak than in households with three or more persons (Electricity Association, 1998).

Outside and inside security lighting is becoming more popular (50 % of people surveyed used lighting for security often or always, Electricity Association, 1998) and as yet no provision has been made in energy budgets for security lighting at ZED.

2.2.4 Electrical Appliances

Appliance consumption has almost doubled in the last 25 years (DECADE, 1997a) due to the increase of affordable electrical goods on the market. Table 2.5 shows energy consumption data for the present market best and worst appliances. Appendix D shows consumption data for most average household appliances. For most households the largest contributors to appliance consumption are the cold appliances.

Table 2.5 Annual energy consumption values for products on the market in 1998 (Boardman, 1998).

	Market best (kWh pa per household)	Market worst (kWh pa per household)
Fridge-freezer	330	970
Dishwasher	260	530
Oven	150	350
Tumble dryer	210	250
Washing machine	140	510

2.2.4.1 Cold Appliances

Electricity consumption for cold appliances has fallen since the 1980s as research has enabled reduction in the electrical demand of these appliances and the new improved products have become available at competitive prices (DECADE 1997a).

In 1996, domestic cold appliances used 24 % of electricity consumed by UK domestic lights and appliances, and 6 % of total UK electricity consumption (more than all the electricity consumed in offices in the UK). The average household owns 1.4 cold appliances (1.2 in low income homes), of which most are replaced after 14 years. Therefore, 2.3 million households purchase a new cold appliance each year (DECADE, 1997b). Ownership percentages and average electricity consumption for cold appliances can be found in table 2.6.

Table 2.6 Percentage of households in the UK owning cold appliances and the average energy consumption values for typical new appliances and older stock appliances (DECADE, 1997a).

	Ownership %	New appliances kWh pa	Stock appliances kWh pa
Refrigerator	43	270	320
Fridge-freezer	60	590	640
Upright freezer	24	420	500
Chest freezer	18	420	510

Frost-free appliances are having an increasing share of the market (28 % of fridge-freezers and 11 % of upright freezers). The facility increases energy consumption by 45 % and the price is also significantly higher. At present, the method of calculating the efficiency of the appliance, for both the label and for minimum standards, allows a concession for frost-free (DECADE, 1997b).

65 % of low income houses have working but faulty cold appliances, which are over consuming electricity. Therefore, the low energy fridges to be offered at ZED, will reduce the energy consumption further for low income households than for average income households, thus reducing the running costs more.

Vacuum insulation panels (VIPs) are currently being introduced into cold appliances. This technology reduces energy consumption by 80 % compared to the average 1992 cold appliance (DECADE, 1997a). It is hoped that by the time ZED residents will choose their cold appliances, these VIPs will be cheap enough to be recommended to low-income families as well as higher income families.

2.2.4.2 Energy Labels

Energy labels provide the customer with a way to rate different appliances on their energy efficiency. A survey of 100 purchasers, discovered that 35 used the energy label and bought appliances that were, on average, 20 % more efficient than those bought by people not influenced by the label.

However, manufactures are allowed an error of 15 % on their energy demand values and 3 % on volume. When combined, the efficiency index can be 17.25 % different to the actual value/index, which is equivalent to two classes of the energy label. Only a little over a third of appliances independently tested were shown to be in the energy class declared on their label. A quarter of the tested appliances show a discrepancy of two, three or four classes on the label - always towards higher efficiency. In 41 % of cases the discrepancy was greater than 15 %, one in five tested by consumer groups showed consumption to be greater than 25 % out from that stated on the label (DECADE, 1997b).

Therefore, although energy labels give a guide to the energy performance of the appliance, further research must be done in order to ensure that ZED residents get the most energy efficient on the market. Which? magazine and Ethical Consumer have carried out studies into electrical appliances. The ELDA database can provide information to help customers rank models according to their priorities and enable life-cycle costs to be calculated. The ELDA database is a comprehensive database of domestic electrical appliances containing all relevant product information including energy efficiency and performance. The database was developed in Denmark and is used by Danish utilities to advise consumers on the most suitable appliance for their needs. Scottish Hydro Electric is currently involved in a project to adapt the database for use in their shops by entering data on appliances available in the UK (DECADE, 1997a).

Boardman, 1998 gives a general idea of the range of efficiencies of appliances. If an average refrigerator is given an efficiency index of 100 units, then an average new version would be 84 units, the best available on the market in the UK would be 44 units, the best in stock available anywhere would be 26 units. In many cases the appliances between 84 and 44 can be bought for no extra cost.

Some EU Member States and some utilities offer rebates on efficient cold appliances. Consumers in high socio-economic groups are more likely to concentrate on the energy use of different appliances when making a purchase, whilst less affluent consumers concentrate more on price. The Energy Savings Trust has funds to provide a rebate so low-income households with an inefficient, old refrigerator can obtain a more energy efficient one (label B/C) (Boardman, 1997). Grants may be available to subsidise the costs of new appliances for the social housing at ZED.

2.2.4.3 Wet Appliances

Wet appliances are also a major contributor to the energy consumption of a household. At ZED it is recommended that occupants will not have tumble dryers, as they have a high electricity demand. Convenient drying facilities will be provided. However, dishwashers have been incorporated in the energy calculations.

For washing machines, this report has assumed an energy consumption of 0.6 kWh per cycle. This is the lowest figure found in manufacture's brochures, for a cycle at 60 °C. Energy consumption of washing machines, and dishwashers can vary greatly depending on owner usage patterns, e.g. a 40 °C wash uses only 70 % of the electricity used by a 60 °C wash (DECADE, 1997a).

2.2.4.4 Audio-visual Appliances (brown goods)

Televisions (TVs) and video recorders (VCRs) are responsible for 84 % of the energy consumption of household brown goods. VCRs have not been included in the energy calculations for ZED dwellings, but as a general guide, they use a similar amount to the TV.

Table 2.7 Average energy consumption figures for TVs and VCRs for 1996. "New" refers to the new products on the market, "average" to the average appliance in stock (DECADE, 1997a).

		% own	New (W)	Average kWh pa
TV	On mode	179	69	118
	Standby		7	
VCR	On mode	89	25	104
	Standby		9	

Brown goods on average consume around 12.5 % of all the electricity used for UK domestic lighting and appliances. Consumption by televisions is expected to increase as surround sound and larger screens consume more electricity. Cable and satellite decoders use a significant amount of electricity in their standby mode (DECADE, 1997a) and again have not been incorporated in this study. By the year 2000 standby wattage should be reduced to 7.5 W and 9.5 W for TVs and VCRs respectively, according to a voluntary agreement produced by the European Association of Consumer Electronics Manufacturing (EACEM), and thereafter by 1 W per year for the next 3 years. However TVs and VCRs have already been developed with 0.1 W power demands with TVs at 0.5 W and VCRs at 1.0 W being cost effective (DECADE, 1997a). Therefore, it will be well worth researching the most energy efficient televisions and VCRs (as well as white goods) to recommend to the future ZED occupants.

2.2.4.3 Miscellaneous Appliances

Ownership of electric power showers is increasing and they are a major consumer of electricity in the miscellaneous group of appliances (ie. excluding white goods, brown goods, lighting and cooking appliances) (DECADE, 1997a). Power showers are not recommended for ZED but shower design should, therefore, be good enough to mean that occupants do not wish to replace the installed shower with an electric power shower.

2.3 Domestic Electricity Consumption at ZED

Occupancy patterns and lifestyles can affect the electricity consumption in identical buildings by up to 4 or 5 times (Twinn, 1999 and NES, 1999). In order to predict electrical energy consumption at ZED, worst, typical and best case scenarios have been considered.

All energy demands have been calculated using data from company brochures for energy efficient appliances such as those that will be recommended for installation at ZED. For some appliances, such as kettles, there is no energy efficient option so typical energy consumption values have been used.

For each unit type available at ZED, various possible family types have been considered. In the following pages, tables of predicted usage patterns for each appliance, for each family type and for each scenario give predicted electrical energy consumption values. These energy demands are summarised to show predicted electricity consumption for each appliance and predicted total electricity consumption by each family type for each scenario.

2.3.1 Appliance Usage Tables

The following Tables 2.8 – 2.28 show the predicted energy consumption for lighting, cooking and major appliances by the different family types living in each house type. Each table shows a different appliance.

Table 2.8 Fridge - worst case scenario families.

Unit type	Family types	Fridge type	Make	Model	Volume (fridge / freeze box l)	kWh pa
1 bed flat	Young single person	Freezebox	Miele	K 1357S-6	131/18	255.5
	Old single person	Freezebox	Miele	K 1357S-7	131/18	255.5
	Young couple	Freezebox	Miele	K 1357S-8	131/18	255.5
	Old couple	Freezebox	Miele	K 1357S-9	131/18	255.5
2 bed flat	Single person	Freezebox	Whirlpool	ART 592/G	200/22	230
	Young couple	Freezebox	Miele	K 1357S-11	131/23	255.5
	Old couple	Freezebox	Miele	K 1357S-12	131/23	255.5
	Family, 1 child	Freezebox	Whirlpool	ART 592/G	200/22	230
	Family, 2 children	Freezebox	Whirlpool	ART 592/G	200/22	230
3 bed maisonette	Family, 1 child	Freezebox	Whirlpool	ART 592/G	200/22	230
	Family, 2 children	Freezebox	Whirlpool	ART 592/G	200/22	230
	Family, 3 children	Freezebox	Whirlpool	ART 592/G	200/22	230
3/4 bed town house	Family, 1 child	Freezebox	Whirlpool	ART 592/G	200/22	230
	Family, 2 children	Freezebox	Whirlpool	ART 592/G	200/22	230
	Family, 3 children	Freezebox	Whirlpool	ART 592/G	200/22	230
	Family, 4 children	Freezebox	Whirlpool	ART 592/G	200/22	230

Table 2.9 Fridge - typical families.

Unit type	Family types	Fridge type	Make	Model	Volume (l)	kWh pa
1 bed flat	Young single person	larder	AEG	OKO-SANTO 1643 TK	143	146
	Old single person	Larder	AEG	OKO-SANTO 1643 TK	143	146
	Young couple	Larder	AEG	OKO-SANTO 1643 TK	143	146
	Old couple	Larder	AEG	OKO-SANTO 1643 TK	143	146
2 bed flat	Single person	Larder	AEG	OKO-SANTO 1643 TK	143	146
	Young couple	Larder	AEG	OKO-SANTO 1643 TK	143	146
	Old couple	Larder	AEG	OKO-SANTO 1643 TK	143	146
	Family, 1 child	Larder	AEG	OKO-SANTO 1643 TK	143	146
	Family, 2 children	Larder	AEG	OKO-SANTO 1643 TK	143	146
3 bed maisonette	Family, 1 child	Larder	AEG	OKO-SANTO 1643 TK	143	146
	Family, 2 children	Larder	AEG	OKO-SANTO 1643 TK	143	146
	Family, 3 children	Larder	Whirlpool	ART 590/G	245	193
3/4 bed town house	Family, 1 child	Larder	AEG	OKO-SANTO 1643 TK	143	146
	Family, 2 children	Larder	AEG	OKO-SANTO 1643 TK	143	146
	Family, 3 children	Larder	Whirlpool	ART 590/G	245	193
	Family, 4 children	Larder	Whirlpool	ART 590/G	245	193

Table 2.10 Fridge - best case scenario families.

Unit type	Family types	Fridge type	Make	Model	Volume (l)	kWh pa
1 bed flat	Young single person	larder	AEG	OKO-SANTO super 1673 TK	150	127.75
	Old single person	larder	AEG	OKO-SANTO super 1673 TK	150	127.75
	Young couple	larder	AEG	OKO-SANTO super 1673 TK	150	127.75
	Old couple	larder	AEG	OKO-SANTO super 1673 TK	150	127.75
2 bed flat	Single person	larder	AEG	OKO-SANTO super 1673 TK	150	127.75
	Young couple	larder	AEG	OKO-SANTO super 1673 TK	150	127.75
	Old couple	larder	AEG	OKO-SANTO super 1673 TK	150	127.75
	Family, 1 child	larder	AEG	OKO-SANTO super 1673 TK	150	127.75
	Family, 2 children	larder	AEG	OKO-SANTO super 1673 TK	150	127.75
3 bed maisonette	Family, 1 child	larder	AEG	OKO-SANTO super 1673 TK	150	127.75
	Family, 2 children	larder	AEG	OKO-SANTO super 1673 TK	150	127.75
	Family, 3 children	larder	AEG	OKO-SANTO super 1673 TK	150	127.75
3/4 bed town house	Family, 1 child	larder	AEG	OKO-SANTO super 1673 TK	150	127.75
	Family, 2 children	larder	AEG	OKO-SANTO super 1673 TK	150	127.75
	Family, 3 children	larder	Siemens	KI26 R40 GB	220	146
	Family, 4 children	larder	Siemens	KI26 R40 GB	220	146

Table 2.11 Fridgefreezer - worst case scenario families.

Unit type	Family types	Make	Model	Volume (l)	kWh pa
1 bed flat	Young single person	Zanussi	ZFD50/17R	136/42	358
	Old single person	Zanussi	ZFD50/17R	136/42	358
	Young couple	Zanussi	ZFD50/17R	136/42	358
	Old couple	Zanussi	ZFD50/17R	136/42	358
2 bed flat	Single person	Zanussi	ZFD50/17R	136/42	358
	Young couple	Zanussi	ZFD50/17R	136/42	358
	Old couple	Zanussi	ZFD50/17R	136/42	358
	Family, 1 child	Hotpoint	RF14	164/60	394
	Family, 2 children	Hotpoint	RF15	164/61	394
3 bed maisonette	Family, 1 child	Hotpoint	RF64	163/106	449
	Family, 2 children	Hotpoint	RF65	163/106	449
	Family, 3 children	Hotpoint	RF66	163/106	449
3/4 bed town house	Family, 1 child	Siemens	KG31 V04GB	193/103	456
	Family, 2 children	Siemens	KG31 V04GB	193/103	456
	Family, 3 children	Siemens	KG33 E01GB	190/126	438
	Family, 4 children	Siemens	KG33 E01GB	190/126	438

Table 2.12 Fridgefreezer - typical families.

Unit type	Family types	Make	Model	Volume (l)	kWh pa
1 bed flat	Young single person	Whirlpool	ART 507/G	145/42	347
	Old single person	Whirlpool	ART 507/G	145/42	347
	Young couple	Whirlpool	ART 507/G	145/42	347
	Old couple	Whirlpool	ART 507/G	145/42	347
2 bed flat	Single person	Whirlpool	ART 507/G	145/42	347
	Young couple	Whirlpool	ART 507/G	145/42	347
	Old couple	Whirlpool	ART 507/G	145/42	347
	Family, 1 child	AEG	OKO-SANTO 2942i	210/70	401
	Family, 2 children	AEG	OKO-SANTO 2942i	210/70	401
3 bed maisonette	Family, 1 child	Siemens	KG33 E01GB	190/126	438
	Family, 2 children	Siemens	KG33 E01GB	190/126	438
	Family, 3 children	Siemens	KG33 E01GB	190/126	438
3/4 bed town house	Family, 1 child	Siemens	KG33 E01GB	190/126	438
	Family, 2 children	Siemens	KG33 E01GB	190/126	438
	Family, 3 children	Siemens	KG33 E01GB	190/126	438
	Family, 4 children	Siemens	KG33 E01GB	190/126	438

Table 2.13 Fridgefreezer - best case scenario families.

Unit type	Family types	Make	Model	Volume (l)	kWh pa
1 bed flat	Young single person	Zanussi	ZO25	196/44	274
	Old single person	Zanussi	ZO25	196/44	274
	Young couple	Zanussi	ZO25	196/44	274
	Old couple	Zanussi	ZO25	196/44	274
2 bed flat	Single person	Electrolux	vacuum panel	198/115 gross	252
	Young couple	Zanussi	ZO25	196/44	274
	Old couple	Zanussi	ZO25	196/44	274
	Family, 1 child	Zanussi	ZO25	196/44	252
	Family, 2 children	Electrolux	vacuum panel	198/115 gross	252
3 bed maisonette	Family, 1 child	Electrolux	vacuum panel	198/115 gross	252
	Family, 2 children	Electrolux	vacuum panel	198/115 gross	252
	Family, 3 children	Electrolux	vacuum panel	198/115 gross	252
3/4 bed town house	Family, 1 child	Electrolux	vacuum panel	198/115 gross	252
	Family, 2 children	Electrolux	vacuum panel	198/115 gross	252
	Family, 3 children	Electrolux	vacuum panel	198/115 gross	252
	Family, 4 children	Electrolux	vacuum panel	198/115 gross	252

Table 2.14 Freezer - worst case scenario families.

Unit type	Family types	Make	Model	Volume (l)	kWh pa
1 bed flat	young single person	Hotpoint	RZ64	103	292
	old single person	Hotpoint	RZ65	103	292
	young couple	Hotpoint	RZ66	103	292
	old couple	Hotpoint	RZ67	103	292
2 bed flat	single person	Hotpoint	RZ70	103	292
	young couple	Hotpoint	RZ69	103	292
	old couple	Hotpoint	RZ70	103	292
	family, 1 child	Miele	F3425S06	186	343
	family, 2 children	Miele	F3425S06	186	343
3 bed maisonette	family, 1 child	Miele	F3425S06	186	343
	family, 2 children	Siemens	GT37 KO4	368	398
	family, 3 children	Siemens	GT37 KO4	368	398
3/4 bed town house	family, 1 child	Miele	F3425S06	186	343
	family, 2 children	Siemens	GT37 KO4	368	398
	family, 3 children	Siemens	GT37 KO4	368	398
	family, 4 children	Siemens	GT37 KO4	368	398

Table 2.15 Freezer - typical families.

Unit type	Family types	Make	Model	Volume (l)	kWh pa
1 bed flat	Young single person	Electrolux	EU0562C	50	248
	Old single person	Electrolux	EU0562C	50	248
	Young couple	Electrolux	EU0562C	50	248
	Old couple	Electrolux	EU0562C	50	248
2 bed flat	Single person	Electrolux	EU0562C	50	248
	Young couple	Electrolux	EU0562C	50	248
	Old couple	Electrolux	EU0562C	50	248
	Family, 1 child	AEG	ARCTIS 1244 iU	100	233
	Family, 2 children	AEG	ARCTIS 1244 iU	100	233
3 bed maisonette	Family, 1 child	Electrolux	EU0562C	50	233
	Family, 2 children	Electrolux	EU0562C	50	233
	Family, 3 children	AEG	ARCTIS super 2773 GS	228	277
3/4 bed town house	Family, 1 child	AEG	ARCTIS super 2773 GS	228	277
	Family, 2 children	AEG	ARCTIS super 2773 GS	228	277
	Family, 3 children	AEG	ARCTIS super 3673 GS	307	328
	Family, 4 children	AEG	ARCTIS super 3673 GS	307	328

Table 2.16 Freezer - best case scenario families.

Unit type	Family types	Make	Model	Volume (l)	kWh pa
1 bed flat	Young single person	AEG	ARCTIS super 2073 GS	96	204
	Old single person	AEG	ARCTIS super 2073 GS	96	204
	Young couple	AEG	ARCTIS super 2073 GS	96	204
	Old couple	AEG	ARCTIS super 2073 GS	96	204
2 bed flat	Single person	AEG	ARCTIS super 2073 GS	96	204
	Young couple	AEG	ARCTIS super 2073 GS	96	204
	Old couple	AEG	ARCTIS super 2073 GS	96	204
	Family, 1 child	AEG	ARCTIS super 2073 GS	96	204
	Family, 2 children	Miele	GT 260 E-6 chest	245	193
3 bed maisonette	Family, 1 child	AEG	ARCTIS super 2073 GS	96	204
	Family, 2 children	Miele	GT 260 E-6 chest	245	193
	Family, 3 children	Miele	GT 260 E-6 chest	245	193
3/4 bed town house	Family, 1 child	Miele	GT 260 E-6 chest	245	193
	Family, 2 children	Miele	GT 260 E-6 chest	245	193
	Family, 3 children	Miele	GT 260 E-6 chest	245	193
	Family, 4 children	Miele	GT 260 E-6 chest	245	193

Table 2.17 Washing machine
Based on any Siemens 0.6 kWh per 60°C cycles.
(DECADE, 1997a, found the average households demand was 270 washes per year in 1996)

Unit type	Family types	Worst case	kWh pa	Typical case	kWh pa	Best case	kWh pa
1 bed flat	Young single person	every day	219	twice a wk	62	once a wk	31
	Old single person	every day	219	twice a wk	62	once a wk	31
	Young couple	every day	219	twice a wk	62	once a wk	31
	Old couple	every day	219	twice a wk	62	once a wk	31
2 bed flat	Single person	every day	219	twice a wk	62	once a wk	31
	Young couple	every day	219	twice a wk	62	once a wk	31
	Old couple	every day	219	twice a wk	62	once a wk	31
	Family, 1 child	twice a day	438	five a wk	156	four a wk	125
	Family, 2 children	twice a day	438	every day	219	four a wk	125
3 bed maisonette	Family, 1 child	twice a day	438	five a wk	156	four a wk	125
	Family, 2 children	twice a day	438	every day	219	five a wk	156
	Family, 3 children	twice a day	438	every day	219	five a wk	156
3/4 bed town house	Family, 1 child	twice a day	438	five a wk	156	four a wk	125
	Family, 2 children	twice a day	438	every day	219	five a wk	156
	Family, 3 children	twice a day	438	every day	219	five a wk	156
	Family, 4 children	twice a day	438	every day	219	every day	219

Table 2.18 Dishwasher
Based on a 1.4 kWh normal cycle.

Unit type	Family types	Worst case	kWh pa	Typical case	kWh pa	Best case	kWh pa
1 bed flat	young single person	every day	438	three a wk	187	twice a wk	125
	old single person	every day	438	three a wk	187	once a wk	62
	young couple	every day	438	three a wk	187	twice a wk	125
	old couple	every day	438	three a wk	187	once a wk	62
2 bed flat	single person	every day	438	three a wk	187	once a wk	62
	young couple	every day	438	three a wk	187	twice a wk	125
	old couple	every day	438	three a wk	187	once a wk	62
	family, 1 child	every day	438	four a wk	250	twice a wk	125
	family, 2 children	twice a day	876	four a wk	250	twice a wk	125
3 bed maisonette	family, 1 child	every day	438	four a wk	250	twice a wk	125
	family, 2 children	twice a day	876	four a wk	250	three a wk	187
	family, 3 children	twice a day	876	five a wk	312	four a wk	250
3/4 bed town house	family, 1 child	every day	438	four a wk	250	twice a wk	125
	family, 2 children	twice a day	876	four a wk	250	three a wk	187
	family, 3 children	twice a day	876	every day	438	four a wk	250
	family, 4 children	twice a day	876	every day	438	five a wk	312

Table 2.19 Microwave
Based on an 800W appliance.

Unit type	Family types	Worst case (mins/day)	kWh pa	Typical case (mins/day)	kWh pa	Best case (mins/day)	kWh pa
1 bed flat	Young single person	60	292	10	49	2	10
	Old single person	60	292	10	49	2	10
	Young couple	60	292	10	49	2	10
	Old couple	60	292	10	49	2	10
2 bed flat	Single person	60	292	10	49	2	10
	Young couple	60	292	10	49	2	10
	Old couple	60	292	10	49	2	10
	Family, 1 child	75	365	15	73	5	24
	Family, 2 children	75	365	15	73	5	24
3 bed maisonette	Family, 1 child	75	365	15	73	5	24
	Family, 2 children	75	365	20	98	5	24
	Family, 3 children	90	438	20	98	10	49
3/4 bed town house	Family, 1 child	75	365	15	73	5	24
	Family, 2 children	75	365	15	73	5	24
	Family, 3 children	90	438	20	98	10	49
	Family, 4 children	90	438	20	98	10	49

Table 2.20 Oven
Based on a 2.5 kW oven.
DECADE, 1997a, found in 1996 the average UK household used 277 kWh of electricity by using the oven.

Unit type	Family types	Worst case (mins/day)	kWh pa	Typical case (mins/day)	kWh pa	Best case (mins/day)	kWh pa
1 bed flat	Young single person	18	274	15	228	10	152
	Old single person	18	274	15	228	10	152
	Young couple	18	274	15	228	10	152
	Old couple	18	274	15	228	10	152
2 bed flat	Single person	20	304	18	274	12	183
	Young couple	20	304	18	274	12	183
	Old couple	20	304	18	274	12	183
	Family, 1 child	20	304	18	274	12	183
	Family, 2 children	20	304	18	274	12	183
3 bed maisonette	Family, 1 child	25	380	20	304	15	228
	Family, 2 children	25	380	20	304	15	228
	Family, 3 children	25	380	20	304	15	228
3/4 bed town house	Family, 1 child	30	456	25	380	20	304
	Family, 2 children	30	456	25	380	20	304
	Family, 3 children	30	456	25	380	20	304
	Family, 4 children	30	456	25	380	20	304

Table 2.21 Hob
Based on a set of four rings totalling 6.6 kW.
The average household consumed 270 kWh of electricity using the hob in 1996 (DECADE, 1997a).

Unit type	Family types	Worst case (mins/day)	kWh pa	Typical case (mins/day)	kWh pa	Best case (mins/day)	kWh pa
1 bed flat	Young single person	20	201	15	151	10	100
	Old single person	20	201	15	151	10	100
	Young couple	25	251	20	201	15	151
	Old couple	25	251	20	201	15	151
2 bed flat	Single person	20	301	15	151	10	100
	Young couple	25	251	20	201	15	151
	Old couple	25	251	20	201	15	151
	Family, 1 child	30	301	23	231	18	181
	Family, 2 children	35	351	27	271	20	201
3 bed maisonette	Family, 1 child	30	301	23	231	18	181
	Family, 2 children	35	351	27	271	20	201
	Family, 3 children	40	402	30	301	25	251
3/4 bed town house	Family, 1 child	30	301	23	231	18	181
	Family, 2 children	35	351	27	271	20	201
	Family, 3 children	40	402	30	301	25	251
	Family, 4 children	45	452	32	321	28	281

Table 2.22 Kettle
Based on an average kettle boiling 12 pints of water for 1 kWh.

Unit type	Family types	Worst case		Typical case		Best case	
		Pints/day	kWh pa	Pints/day	kWh pa	Pints/day	kWh pa
1 bed flat	Young single person	18	547	4	122	2	61
	Old single person	18	547	4	122	2	61
	Young couple	18	547	6	183	2	61
	Old couple	18	547	6	183	2	61
	Single person	18	547	4	122	2	61
2 bed flat	Young couple	18	547	6	183	2	61
	Old couple	18	547	6	183	2	61
	Family, 1 child	18	547	6	183	2	61
	Family, 2 children	18	547	8	243	4	122
3 bed maisonette	Family, 1 child	18	547	6	183	2	61
	Family, 2 children	18	547	8	243	4	122
	Family, 3 children	18	547	10	304	5	152
3/4 bed town house	Family, 1 child	18	547	6	183	2	61
	Family, 2 children	18	547	8	243	4	122
	Family, 3 children	18	547	10	304	5	152
	Family, 4 children	18	547	10	304	6	183

Table 2.23 Toaster
Based on 1kWh giving 60 slices of toast (Electricity Association, 1993).

Unit type	Family types	Worst case		Typical case		Best case	
		Slices/day	kWh pa	Slices/day	kWh pa	Slices/day	kWh pa
1 bed flat	Young single person	6	36.5	2	12	1	12
	Old single person	6	36.5	2	12	1	12
	Young couple	12	73	4	24	2	12
	Old couple	12	73	4	24	2	12
2 bed flat	Single person	6	36.5	2	12	1	12
	Young couple	12	73	4	24	2	12
	Old couple	12	73	4	24	2	12
	Family, 1 child	18	109.5	6	36.5	3	24
	Family, 2 children	24	146	8	49	4	24
3 bed maisonette	Family, 1 child	18	109.5	6	36.5	3	24
	Family, 2 children	24	146	8	49	4	24
	Family, 3 children	30	182.5	10	61	5	36.5
3/4 bed town house	Family, 1 child	18	109.5	6	36.5	3	24
	Family, 2 children	24	146	8	49	4	24
	Family, 3 children	30	182.5	10	61	5	36.5
	Family, 4 children	36	219	12	73	6	36.5

Table 2.24 Hairdryer
Based on a 500W hairdryer (Electricity Association, 1993).

Unit type	Family types	Worst case (mins/day)	kWh pa	Typical case (mins/day)	kWh pa	Best case (mins/day)	kWh pa
1 bed flat	young single person	20	61	10	30	2	6
	old single person	20	61	5	15	2	6
	young couple	20	61	10	30	2	6
	old couple	20	61	5	15	2	6
2 bed flat	Single person	20	61	10	30	2	6
	young couple	20	61	10	30	2	6
	old couple	20	61	5	15	2	6
	Family, 1 child	20	61	10	30	2	6
	Family, 2 children	30	91	10	30	2	6
3 bed maisonette	Family, 1 child	20	61	10	30	2	6
	Family, 2 children	30	91	10	30	2	6
	Family, 3 children	40	122	1	46	5	15
3/4 bed town house	Family, 1 child	20	61	10	30	2	6
	Family, 2 children	30	91	10	30	2	6
	Family, 3 children	40	122	15	46	5	15
	Family, 4 children	50	152	20	61	8	24

Table 2.25 Computer
Based on a 75 W Compaq Presario 2282 (Compaq, 1999).

Unit type	Family types	Worst case (hrs/day)	kWh pa	Typical case (hrs/day)	kWh pa	Best case (hrs/day)	kWh pa
1 bed flat	young single person	16	438	2	55	0	0
	old single person	16	438	0	0	0	0
	young couple	16	438	2	55	0	0
	old couple	16	438	0	0	0	0
2 bed flat	single person	16	438	2	55	0	0
	young couple	16	438	2	55	0	0
	old couple	16	438	0	0	0	0
	family, 1 child	16	438	2	55	0	0
	family, 2 children	16	438	2	55	0	0
3 bed maisonette	family, 1 child	16	438	2	55	0	0
	family, 2 children	16	438	3	82	0	0
	family, 3 children	16	438	4	110	0	0
3/4 bed town house	family, 1 child	16	438	2	55	0	0
	family, 2 children	16	438	3	82	0	0
	family, 3 children	16	438	4	110	0	0
	family, 4 children	16	438	5	137	0	0

Table 2.26 Television
Based on 1kWh giving 6-9 hours viewing (Electricity Association, 1993).

Unit type	Family types	Worst case (hours/day)	kWh pa	Typical case (hours/day)	kWh pa	Best case (hours/day)	kWh pa
1 bed flat	Young single person	16	779	3	146	1	49
	old single person	16	779	5	243	1	49
	Young couple	16	779	4	195	1	49
	old couple	16	779	5	243	1	49
2 bed flat	Single person	16	779	3	146	1	49
	Young couple	16	779	3	146	1	49
	old couple	16	779	5	243	1	49
	Family, 1 child	16	779	5	243	3	146
	Family, 2 children	16	779	5	243	3	146
3 bed maisonette	Family, 1 child	16	779	5	243	3	146
	Family, 2 children	16	779	5	243	3	146
	Family, 3 children	16	779	5	243	3	146
3/4 bed town house	Family, 1 child	16	779	5	243	3	146
	Family, 2 children	16	779	5	243	3	146
	Family, 3 children	16	779	5	243	3	146
	Family, 4 children	16	779	5	243	3	146

Table 2.27 Iron
Based on 1-2 hours use for 1 kWh (Electricity Association, 1993).

Unit type	Family types	Worst case (mins/day)	kWh pa	Typical case (mins/day)	kWh pa	Best case (mins/day)	kWh pa
1 bed flat	young single person	30	137	5	23	2	9
	old single person	30	137	5	23	2	9
	young couple	60	273	10	46	4	18
	old couple	60	273	10	46	4	18
2 bed flat	single person	30	137	5	23	2	9
	young couple	60	273	10	46	4	18
	old couple	60	273	10	46	4	18
	family, 1 child	90	411	15	68	6	27
	family, 2 children	120	548	15	68	8	37
3 bed maisonette	family, 1 child	90	411	15	68	6	27
	family, 2 children	120	548	20	91	8	37
	family, 3 children	150	684	25	114	10	46
3/4 bed town house	family, 1 child	90	411	15	68	6	27
	family, 2 children	120	548	20	91	8	37
	family, 3 children	150	684	25	114	10	46
	Family, 4 children	180	821	30	137	12	55

Table 2.28 Lighting
Based on 1kWh supplying a 20 W CFL low energy light bulb for 40 hours. (Electricity Association, 1993). Also based on data from Electricity Association, 1998, giving data on monitored electrical demand for lighting relative to number of rooms in the house and number of people.

Unit type	Family types	Worst case (kWh pa)	Typical case (kWh pa)	Best case (kWh pa)
1 bed flat	Young single person	252	202	152
	Old single person	252	202	152
	Young couple	271	221	171
	Old couple	271	221	171
2 bed flat	Single person	262	202	142
	Young couple	281	221	161
	Old couple	281	221	161
	Family, 1 child	340	280	220
	Family, 2 children	432	372	312
3 bed maisonette	Family, 1 child	363	293	223
	Family, 2 children	442	372	302
	Family, 3 children	442	372	302
3/4 bed town house	Family, 1 child	360	280	200
	Family, 2 children	452	372	292
	Family, 3 children	460	380	300
	Family, 4 children	460	380	300

2.3.2 Predicted Appliance Energy Consumption

Figure 2.5 shows energy consumption for cooking, lighting and major appliances for the worst, typical and best case scenario households living in ZED houses.

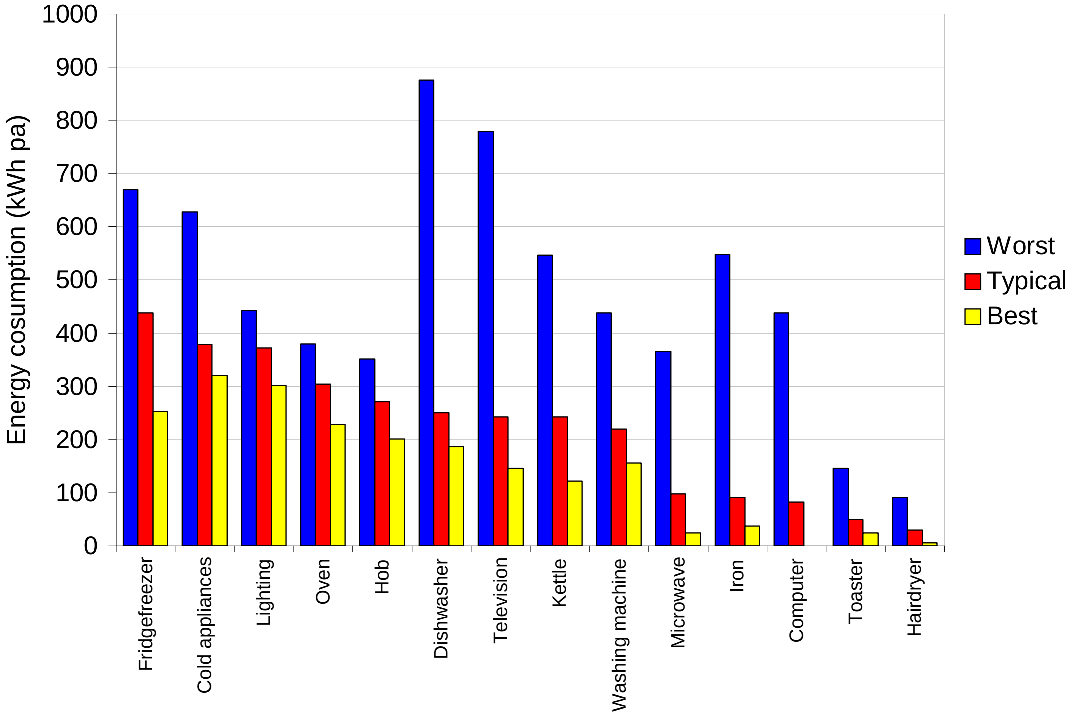

Figure 2.5 Predicted annual energy consumption for lighting, cooking and major appliances for a worst, typical and best case scenario families of four in a ZED three bedroom maisonette.
Cold appliances represent a separate fridge and freezer. A family would either have a fridgefreezer or separate cold appliances.

2.3.3 Total Electrical Energy Consumption

This section shows total predicted electricity demand. In all figures, A represents a one bedroom flat, B a two bed room flat, C a three bedroom maisonette and D a three or four bedroom townhouse.

The following three figures 2.6, 2.7 and 2.8 show the breakdown of predicted annual electricity consumption for all family types in all unit types for lighting, cooking and major appliances. Separate cold appliances have been assumed for the worst case scenario and fridge freezers for typical and best case scenarios.

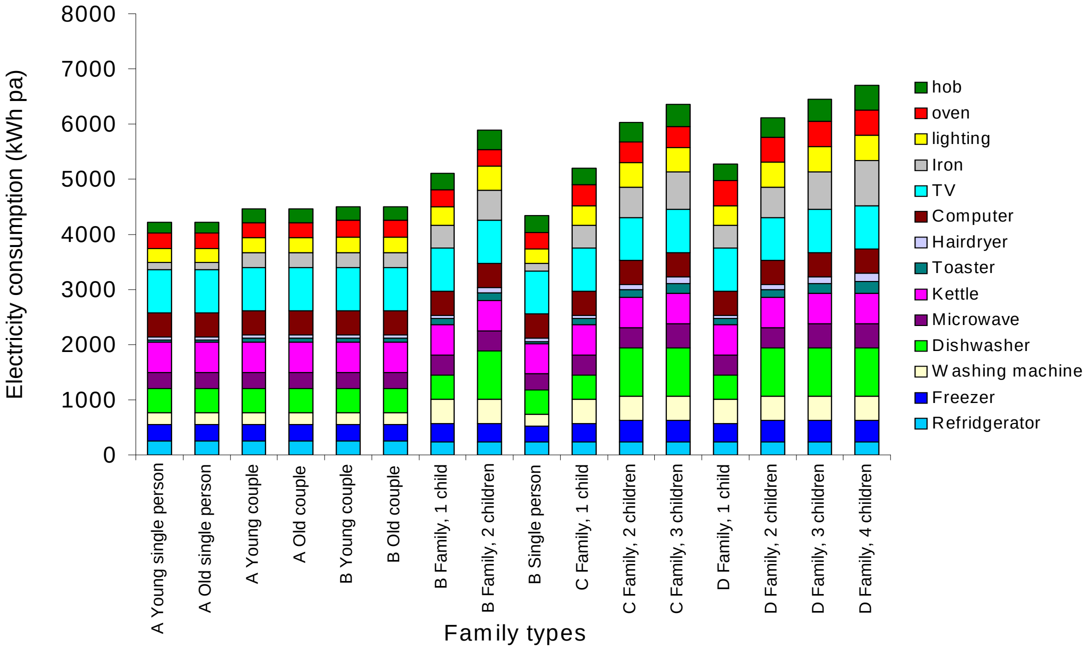

Figure 2.6 Worst case scenario

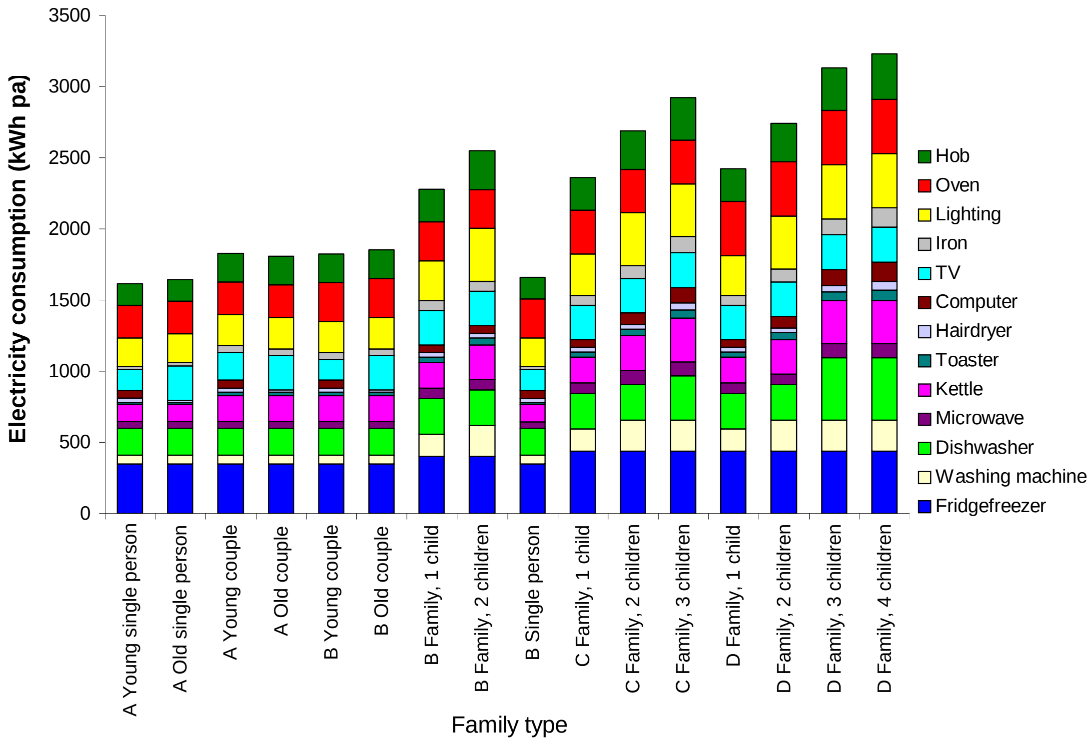

Figure 2.7 Typical Scenario

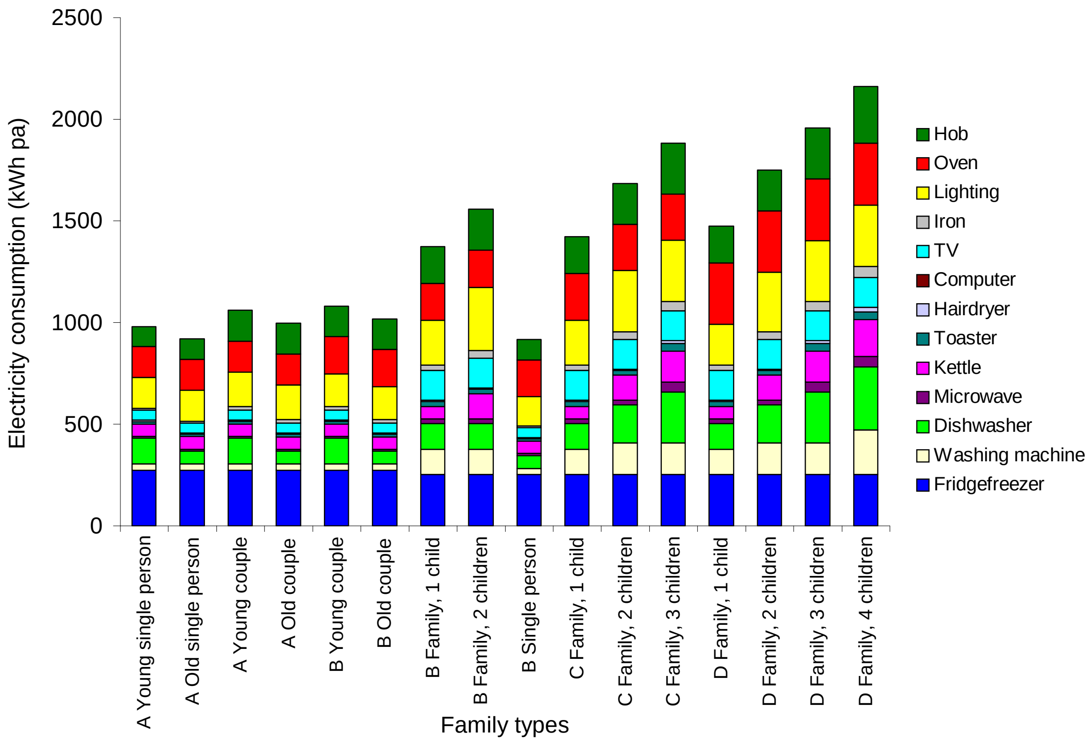

Figure 2.8 Best Case Scenario

Table 2.29 Predicted energy consumption for different family and house types at ZED for cooking, lighting and major appliances. Figures assume separate cold appliances for the worst case scenario and fridgefreezers for typical and best case scenarios.

Unit type	Family type	Worst	Typical	Best
		KWh pa	KWh pa	KWh pa
1 bed flat	Young single	4222	1615	981
	Old single	4222	1642	918
	Young couple	4463	1828	1060
	Old couple	4463	1806	997
2 bed flat	Single person	4336	1660	917
	Young couple	4503	1825	1081
	Old couple	4503	1825	1018
	Family, 1 child	5105	2280	1374
	Family, 2 children	5888	2548	1557
3 bed maisonette	Family, 1 child	5203	2360	1422
	Family, 2 children	6029	2690	1685
	Family, 3 children	6356	2922	1884
3 / 4 bed townhouses	Family, 1 child	5277	2424	1475
	Family, 2 children	6115	2741	1751
	Family, 3 children	6451	3132	1958
	Family, 4 children	6704	3229	2162

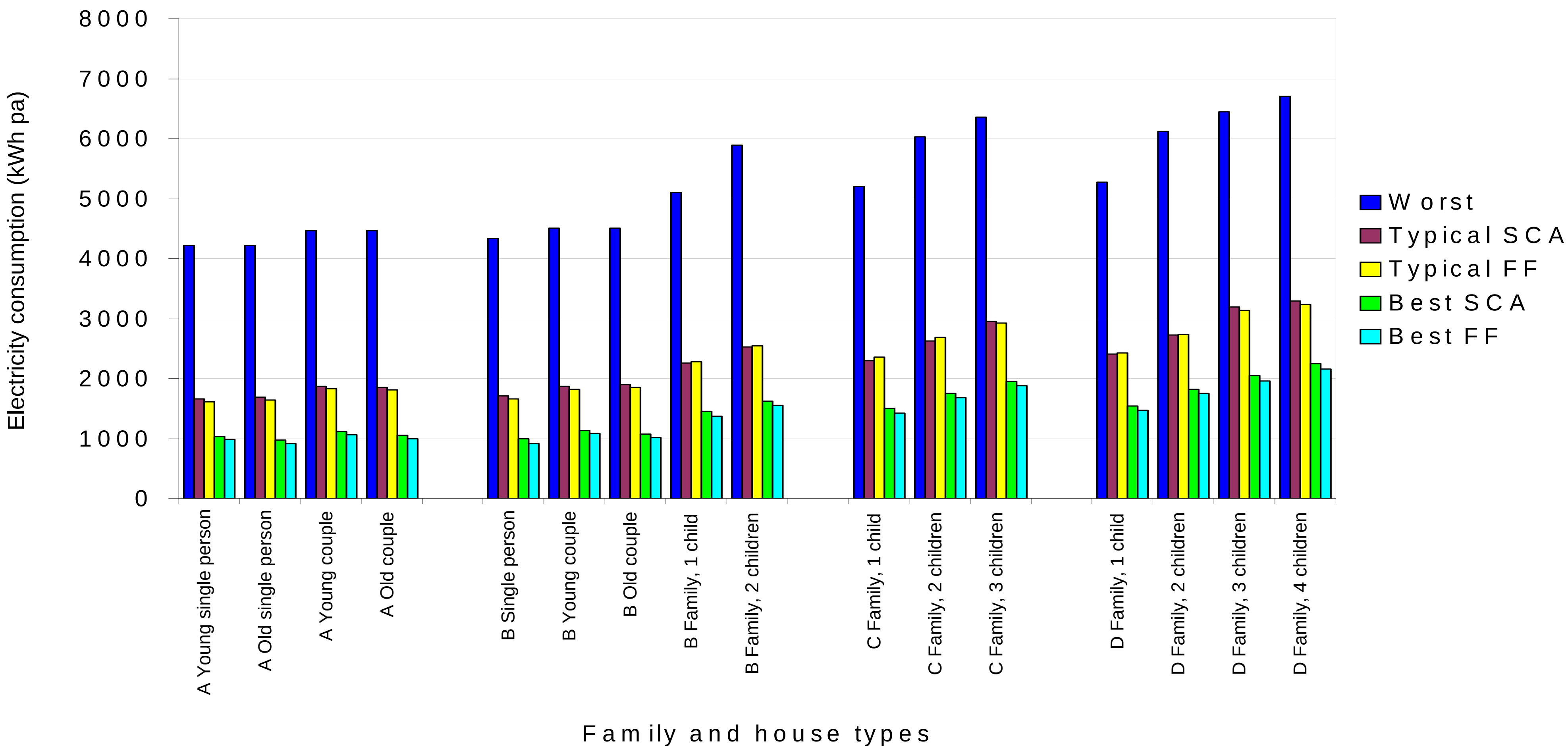

Figure 2.9 Predicted total energy consumption for all family types and house types for lighting, cooking and major appliances. SCA refers to separate cold appliances, FF refers to a fridgefreezer

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Appendix A
Conversion of energy data from the Sutherland Associates 'Comparative Domestic Heating Costs' report.

The report was designed to compare domestic heating costs in seven regions of the United Kingdom and the Republic of Ireland. These heating cost tables have been published every year from 1976. Their intended use is to compare different domestic fuels and the costs of using them under similar conditions. In order to calculate the heating demands of houses, electrical energy consumption was assumed for different types of houses.

ZED is in South East England so figures for this region were used. Three different types of houses were studied; terrace, semi-detached and detached. Assumed energy values from the report were as follows (see table A):

Table A Data for calculating the total energy consumption of different sized houses in the South East of England in 1998. Space and water heating data taken from Sutherland, 1998. Cooking data from Wilson, 1998 and DECADE, 1997a. Lighting and appliance data was taken from DECADE, 1995. Floor areas from Building Research Establishment, (Shorrock, 1999) and Boardman, 1998.

	Sutherland Report Figures (kWh pa)		Add ons (kWh pa)		Totals		
	Space heating	Water heating	Cooking	Lighting and appliances	kWh pa	Floor area m^2	Total kWh pa m^2
Terrace (2 bedrooms)	9500	2000	600	3000	15100	60	252
Semi-detached (3 bedrooms)	13000	2500	600	3000	19100	85	225
Detached (4 bedrooms)	20000	3000	600	3000	26600	120	222

The cooking, lighting and appliance data were added on to give a total energy consumption for the household.

The floor areas used in the original report could not be obtained, therefore average floor areas were assumed, as shown in the table, to gain a figure per m^2. This enabled comparison with other data from differing sized houses. The assumptions were based on:
Boardman, 1998:
- 40 m^2 represents a one bedroom flat,
- 80 m^2 represents an average house
- 120 m^2 represents a detached house.

Shorrock, 1999 - 85 m^2 is an average UK house.
BRE calculations - 85 m^2 for an average house.

Appendix B
Calculation of total household energy consumption from Uglow 1982 data.

The paper tests a simple method of estimating the seasonal energy requirements for space and water heating over a three year period. The heating season lasts for 212 days over which time the amount of 'main' fuel used was measured. The 'main' fuel is that which is used for the majority of the heating. Estimates of how much of this fuel was used for the various components (space heating, water heating, cooking and miscellaneous) were made.

The majority of the houses used gas as their main fuel, for which there were no estimates for miscellaneous items which would be powered by electricity. Those houses using electricity as their main fuel had estimates for all the component parts. Using the estimated values for heating water, cooking and miscellaneous items, energy consumption was calculated for the remaining 153 days to make a full year. This was added to the actual value for the main fuel and converted from GJ to kWh. The final total was divided by the floor area for each dwelling and then means were calculated for each dwelling type.

For example: Semi-detached house of floor area 101.6 m^2 using gas as the main fuel.

Estimated energy consumption over 212 day heating season, GJ.

Space heating	74.9
Water heating	10.9
Cooking	5
Misc. uses	3 (electricity)

Actual main fuel = 76

Actual main fuel + estimated values for electricity = 76 + 3 = 79

Energy not including space heating	= 10.9 + 5 + 3	
	= 18.9	for 212 days
	= 13.64	for 153 days

Total energy for the whole year	= 79 + 13.64 = 92.64 GJ pa
	= 25,733.36 kWh pa
Total energy per m^2	= 25,733.36 / 101.6
	= 253.28 kWh/m^2 pa

Appendix C
Spreadsheet of energy consumption of appliances on the market
Average appliances
1 unit (1 kWh) unless otherwise stated equates to

Battery charger (12 V)		30 hours
Blankets,	Single overblanket	All night for 1-2 weeks
	Double overblanket	All night for 1-3 weeks
	Single underblanket	1.5 hrs 7 nights
	Double underblanket	1.5 hrs 7 nights
Blender		>700 pints of soup
Can opener		1460 cans
Carving knife		208 joints
CFL light bulb (20 W)		>40 hours
Coffee mill		>100 kg of coffee
Coffee percolator		75 cups
Cooker		1 weeks meals for family of 4, ~15 units
Hob		Bacon and egg breakfast for 4 > ½ unit
Radiant Boiling Ring		Chicken stew for 4 > ½ unit
Conventional oven		24 scones
Fan oven		48 meringues, 1¼ units
Cooker grill		2lb pork sausages
Cooker Hood		> 10 hours
Crepe maker		135 crepes
Deep fat fryer		3 lb chips
Dishwasher cold fill		1 load, 2 units
Extractor fan		24 hours
Facial sauna		10 hours
Floor polisher		1 week
Fluorescent strip light (40 W)		> 20 hours
Food mixer		> 52 cakes
Freezer		1-2 units a day
Fridge/freezer		~2 units a day
Hair curling tongs		60, 30 min sessions
Hair dryer (500 W)		12, 10 min sessions
Hair rollers		> 14 hair-dos
Fan heater (2 kW)		30 mins
Infra red heater (1 kW)		1 hour
Kettle		12 pints
Oil filled radiator (500 W)		2 hours
Panel heater (1.5 kW)		40 mins
Portable computer		10 hours
Radiant heater (3 kW)		20 mins
Heating pad (30 kW)		> 30 hours
Headge trimmer		2 ½ hours
Hot food trolley		> 1 hour
Hot tray		2 hours
Instant water heater		> 3 gallons
Iron		1-2 hours
Knife sharpener		12,000 knifes
Lamp (60 W)		16 hours
Lawnmower	Cylinder	3 hours
	Rotary	1 hour

Light bulb (100W)		10 hours
Microwave		6, 20 min meals
Multi-purpose cooker		2 lamb chop casseroles for 4
Powerdrill		4 hours
Refrigerator Larder		> 1 day
Refrigerator with freeze box		~ 1 day
Rotisserie		< 1 ½ hours
Sandwich toaster		6-13 sessions for family of 4
Shaver		every day for 5 years
Shower (7 kW)		3-5 min shower every day, 2 ½ - 4 units
Slow cooker		8 hours
Spin dryer		5 weeks use
Stereo system		10 hours
Tape recorder		> 24 hours
Tea maker		35 cups
Toaster		60 slices
Towel rail (250 kW)		4 hours
Tumble dryer		8 – 12 lb sheets/towels, 4 units
TV 22 inch colour		6-9 hrs
Vacuum cleaner	Cylinder	every day for a week
	Upright	2 hours
Washing machine	Automatic	weekly wash for 4, 8-9 units
Twin tub		weekly wash for 4, 11-12 units
Waste disposer		50 lb rubbish
Yoghurt maker		70 yoghurts

Electricity Association Services Ltd.1368/7.93.

4. PREDICTED ENERGY USE (OVE ARUP AND PARTNERS, 1999)

C PREDICTED ENERGY USE

Predicting a building's energy use with great accuracy is problematic since it depends to a large degree on how the occupant uses the building. Energy use in identical dwellings can vary by a factor of up to 5 depending on occupancy etc. Since the development at Beddington is not very large, these effects will not be entirely averaged out over the site. However, we require estimates on which to base our design for the CHP (combined heat and power) unit, and that is the purpose of this audit.

C1. SITE ELECTRICITY REQUIREMENTS

Our aim is to size the CHP plant such that over the year we produce at least as much electricity as is consumed. We do not aim to cover for peaks in demand - at peak times "green" electricity will be imported from the grid, and an equivalent amount exported to the grid at off peak times. For sizing the CHP, our estimates for electricity use should tend to the generous side so that we are sure of making the site "zero energy". On the other hand, there is at present an inbalance in most electricity companies' import and export tariffs which make it unprofitable to export electricity to the grid. This means we should avoid greatly oversizing the CHP unit. However, the electricity companies' position is changing and we will continue to monitor it since larger CHP units are more economic to buy and run in terms of £ per kW output.

BioRegional Development Group have researched and produced a report with estimates of electrical use in the various building types at Beddington (primarily the dwellings)[i] . The report gives annual energy usage for three cases - "worst", "typical" and "best" calculated based on heavy, reasonable and infrequent use of appliances. The report is useful in highlighting which appliances are the biggest electricity users over the year. However, it should be noted that all the estimates are based on the occupants using energy efficient appliances, so in a sense they are all ideal scenarios. It is impossible to guarantee that all occupants will use energy efficient appliances even if they are offered at attractive prices. While the report goes into good detail on the main appliances found in the dwellings, it might be prudent to include an additional allowance for "miscellaneous" items such as food processors, vacuum cleaners, hi-fi systems, answering machines, electronic musical instruments etc, etc. It should also be borne in mind that one "worst case" family will cancel out about four "best case" families, so the site wide mean is likely to be more that the "typical" figures.

Bearing these issues in mind, we have used the following figures for estimating electrical energy use. We have assumed that all the options for residents in the households as given by BioRegional are equally likely, i.e. there will be roughly equal numbers of flats with single young people / single old people / young couples / elderly couples.

Unit Type	BioRegional "worst" average kWh/annum	BioRegional "typical" average kWh/annum	BioRegional "best" average kWh/annum	Suggested figure for CHP sizing (1worst+4 typical÷5) kWh/annum
1 bed flat	4343	1723	989	2247
2 bed flat	4867	2028	1189	2596
3 bed maisonette	5863	2657	1663	3298
3/4 bed townhouse	6137	2882	2449	3533

This gives reasonable agreement with our original estimate of 11.8 GJ or 3290 kWh/annum for the maisonette.

For the offices we have taken a rate of 54kWh/m^2/annum, based on the DETR good practice rate for a naturally ventilated office[ii]. For the shop we have estimated 396kWh/m^2 (small food shop - good practice)[iii]. Shop energy use is generally very high due to display lighting, refrigeration and so on - the Bed ZED shop would be a good place to try and tackle this. For the nursery 20kWh/m^2 and healthy living centre 44kWh/m^2. Several unknowns remain, such as whether floodlighting is to be installed on the football pitch and the exact functions of the club house and healthy living centre.

For the split of units as proposed by Bill Dunster Architects at the design team meeting on 27th May 1999, and taking into account site infrastructure such as street lighting, this gives a site wide average daily electrical energy use of 5.8 GJ (1,600 kWh). Allowing for 5% losses in distribution, and a 10% design margin, this could be generated by a 110 kW_e CHP unit running 17 hours/day every day.

There will be some seasonal variation in electrical demand (lights are on for longer in winter, etc) but these are not expected to be very great, as illustrated in the BioRegional report.

C2. SITE DISTRICT HEATING REQUIREMENTS

Heat from the CHP is used primarily to heat domestic hot water. It is also used for some supplementary heating via the towel rails and by heating air via the airing cupboards.

With electricity, it is straightforward to import and export electricity from the National Grid to cater for peak demands. With heat there is no such simple solution. One option would be to install a boiler next to the CHP plant to cover peak heat demands, but this would be an expensive solution, with the boiler rarely being used. We would recommend that the buildings are designed so that the CHP size is capable of meeting peak demands, and the system carefully designed with the aim of spreading the heating requirement over the day. Installing very large hot water cylinders in all the properties which can gradually warm up over the day to cover the heavy evening hot water demand will help - this is the same principle as used by off peak (Economy 7) electrically heated water cylinders.

For maximum efficiency, the wood chips for the CHP need to be dried out before being gasified in the CHP. Ideally, this would be on a low priority heating circuit which can take heat when it is available but be shut off when demand elsewhere is high. This would require appropriate design of the CHP installation to provide a storage space for "dry" wood chips.

While the heat required for hot water supply is not expected to vary greatly over the year, the supplementary heating requirement will be greatest in winter. For this reason, our estimates of heat requirements are based on a winter day.

Typical design figures for hot water usage are as follows[iv]

Number of occupants in dwelling	HW use per day (litres)	equivalent heat demand over 24 hours (W)	annual equivalent heat demand (kWh)
1 person	130	348	3045
2 people	141	377	3302
3 people	165	441	3864
4 people	187	500	4380

Water use may be slightly lower at Beddington ZED if people use showers rather than baths and are trying to conserve water, though this is balanced by the fact that we are encouraging the use of hot water for washing machines and dishwashers instead of electrical water heating.

For offices, typical hot water energy requirements are 0.043 kWh/m^2/annum, for a small shop around 0.1 kWh/m^2/annum and for a health clinic 0.2 kWh/m^2/annum[v]. For the club house we have assumed on average 25 showers per day each 6 minutes long. This is a preliminary estimate which may need to be revised when the function and layout of the club house have been more fully defined.

This gives a daily site wide energy requirement for hot water of 3.9 GJ (1070 kWh).

The requirement for additional heating is difficult to quantify. In summer the amounts will be small, though heat will still be used to dry clothes etc and on cooler evenings. Our thermal modelling shows that if the high insulation and low infiltration targets are achieved together with 40% heat reclaim on the ventilation system, no additional heating is required even in winter if the dwellings are occupied. If the dwellings are unoccupied, around 500W (12W/m²) background gains are all that is required to meet heat losses. The heat gains required in unoccupied houses are partially balanced by the fact that when the house is unoccupied there is no hot water demand, saving around 400W (≈ 8.2W/m²). We would estimate the output from a standard heated towel rail to be around 50 to 100W.

To cover the additional heating in sparsely occupied or unoccupied dwellings, we have allowed extra gains of 3.5 W/m² in all dwellings.

For the offices, the heat losses amount to around 900W (11W/m²) at 0.5ach (air changes per hour) with 50% heat reclaim. Since there is no occupancy at night, we have allowed for internal heat gains of 8 W/m² over 24 hours, equivalent to 11 W/m² for 18 hours a day (allowing for some unoccupied offices).

These figures give a daily site wide demand for additional heating on a winter day as around 3.2 GJ (890 kWh), and including the hot water this gives a total daily site heat demand of 7.1 GJ (1960 kWh).

Due to the large distance between the CHP and the dwellings, distribution losses are likely to be substantial. By routing pipework inside buildings where possible, we hope to limit these to around 20%. This compares with about 5% for a modern district heating system and reflects the low heat demand density needed in a low energy development. Pipeline heat "losses" inside buildings will of course help to keep internal spaces warm.

Allowing a 10% design margin, the average heat output required on a winter day from the CHP if it operates for 17 hours/day is 153 kW.

C3. CALCULATION SPREADSHEET

Based on area schedule from Bill Dunster received 27th May 1999

CHP runs	17	hours/day
Heat dist losses	20	%
Elec. dist losses	5	%
additional gains (flat)	3.5	W/m2
additional gains (office)	8	W/m2

HEATING

			W	kWh/annum
1 person	130	litre hot water/day	348	3045
2 people	141		377	3302
3 people	165		441	3864
4 people	187		500	4380
office	0.67	litres/m2	0.043	kWh/m2
shop	1.6	litres/m2	0.103	
nursery	1.6	litres/m2	0.103	
club house	25	shower@6min	810	litres/day
healthy	3.1	litres/m2	0.199	
delta T	55	°C		

ELECTRICITY USE

1 person flat	2247	kWh/annum
2 person flat	2596	
3 person mais	3298	
4 person house	3533	
office	54	kWh/m2/annum
shop	396	
nursery	20	
club house	74	
healthy	44	

maximum	predicted	unit floor	number	predicted total	total floor	per day	Hot water Hot water	Energy	extra heat from towel rail + HW cylin + pipework etc	extra heat	Electric kWh annual

DWELLINGS		people	people	area m2	of units	people	area m2	per unit litres	per day litres	per day MJ	over 24 hours W/m2	W	MJ	per unit kWh	all units kWh	per day MJ
BLOCK A	Flat	2	1	48.5	6	6	291	130	780	180	3.5	170	88	2596	15574.8	153.6
	Maisonette	4	3	75.5	6	18	453	165	990	229	3.5	264	137	3533	21198	209.1
BLOCK B	Flat	2	2	48.5	6	12	291	141	846	195	3.5	170	88	2596	15574.8	153.6
	Maisonette	4	4	75.5	6	24	453	187	1122	259	3.5	264	137	3533	21198	209.1
BLOCK C	Flat	2	1	48.5	6	6	291	130	780	180	3.5	170	88	2596	15574.8	153.6
	Maisonette	4	3	75.5	6	18	453	165	990	229	3.5	264	137	3533	21198	209.1
BLOCK D	Flat	2	2	48.5	5	10	242.5	141	705	163	3.5	170	73	2596	12979	128.0
	Maisonette	4	4	75.5	5	20	377.5	187	935	216	3.5	264	114	3533	17665	174.2
BLOCK E	Maisonette	3	2	62	4	8	248	141	564	130	3.5	217	75	3298	13192.8	130.1
	Maisonette	4	3	75.5	4	12	302	165	660	152	3.5	264	91	3533	14132	139.4
BLOCK F	Flat	3	2	60	5	10	300	141	705	163	3.5	210	91	3298	16491	162.7
	Flat	3	3	60	5	15	300	165	825	191	3.5	210	91	3298	16491	162.7
	Flat	3	2	60	5	10	300	141	705	163	3.5	210	91	3298	16491	162.7
BLOCK G	Maisonette	4	3	75.5	5	15	377.5	165	825	191	3.5	264	114	3533	17665	174.2
	Maisonette	4	4	75.5	5	20	377.5	187	935	216	3.5	264	114	3533	17665	174.2
	Flat	4	3	73.5	3	9	220.5	165	495	114	3.5	257	67	3533	10599	104.5
					82	**213**	**5278**			**2971**			**1596**			**2601**
OFFICES																
BLOCK A	Unit	7.1		85	6	42.5	510	57	341.7	79	8.0	680	353	4590	27540	271.6
BLOCK B	Unit	7.1		85	6	42.5	510	57	341.7	79	8.0	680	353	4590	27540	271.6
BLOCK C	Unit	7.1		85	3	21.3	255	57	170.85	39	8.0	680	176	4590	13770	135.8
					15	**106**	**1275**			**197**			**881**			**679**
OTHER																
SHOP				342	1	20	342	547	547.2	126	8.0	2736	236	135432	135432	1335.8
NURSERY				170	1	20	170	272	272	63	8.0	1360	118	3400	3400	33.5
CLUB HOUSE				110	1	10	110	810	810	187	8.0	880	76	8140	8140	80.3
HEALTHY LIVING CENTRE				440	1	30	440	1364	1364	315	8.0	3520	304	19360	19360	190.9
					4	**80**	**1062**			**691**			**734**			**1641**

	number	W	hours/day	MJ
Streetlights	35	400	14	**706**
Floodlights	8	5000	1	**144**
RW pumps	6	500	2	**22**
Heating pumps	1	500	17	**31**

	units	people	area				
TOTALS	**101**	**399**	**7615**	**3860**	+	**3211**	**5822 MJ/day**
				total heat **7071**			

over CHP hours 115.5 kW

TOTAL HEAT 115.5 kW
losses 23.1 kW
10% design margin 13.9 kW

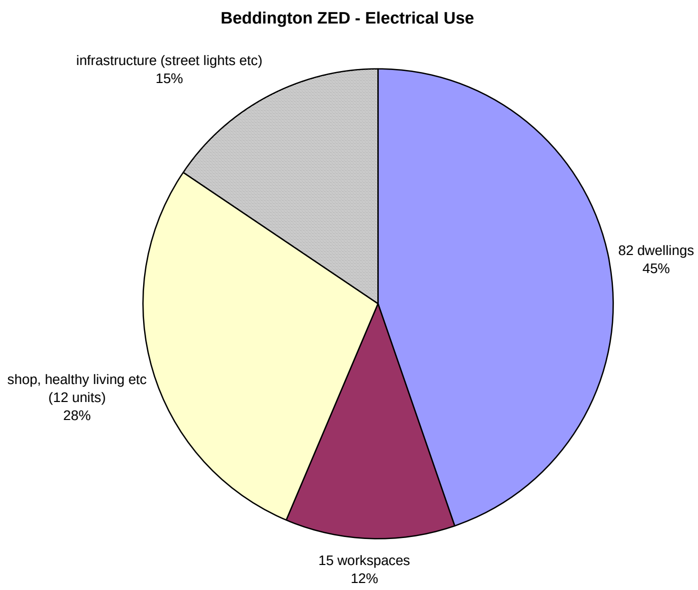
CHP HEAT REQD from heat exchanger: 153 kW

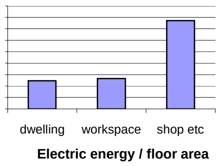
over CHP hours 95.1 kW

TOTAL ELEC 95.1 kW
losses 4.8 kW
10 % design margin 10.0 kW

CHP ELEC REQD output: 110 kW

PROPORTIONS OF ELECTRICAL ENERGY USE





C4. REFERENCES

[i] Beddington ZED Energy Analysis - Caroline Bakewell, BioRegional Development Group, April 1999
[ii] DETR Energy Consumption Guide 19 - Energy Use in Offices, 1998
[iii] Business guide to energy use in buildings - Dept of the Environment 1996
[iv] Arup Building Services Concept Design Guide
[v] Estimates based on ref 4

5. TRANSPORT ENERGY CONSUMPTION

It is predicted that transport energy consumption at BedZED will change over time as the composition of vehicles on site changes. Transport energy consumption will fall as residents and workers reduce car use in favour of public transport, walking and cycling or give up their car to join the car pool. The shift from fossil fuel to electric vehicles will also reduce energy consumption.

A spreadsheet model was created to predict changes in transport energy consumption at BedZED. The model addresses residential transport only. It is assumed that the energy consumption relating to travel to work and travel in the course of work at BedZED is balanced by the energy consumption of BedZED residents travelling to work and in the course of work outside the development.

Scenario	*No. of private vehicles*		*No. of pool car vehicles*		*Transport energy consumption (kWh / year)*
	Fossil fuel	*Electric*	*Fossil fuel*	*Electric*	
Equivalent conventional development	88	0	0	0	963,098
BedZED year 1	74	5	3	2	709,589
BedZED year 5	49	10	4	6	527,679
BedZED year 10	11	28	3	12	244,746

Table 1: The predicted energy consumption of transport at BedZED based on different scenarios of vehicles on site.

The figures shown in table 3 are generated from a model based on a number of assumptions.

5% of the private fossil fuel mileage in the year 1 scenario has been added to the fossil fuel mileage in each scenario to account for energy consumption by services to the site e.g. internet shopping deliveries, refuse and recycling collections.

It is assumed that the average mileage of a fossil fuel car is 18,000km per year (RAC, 1999) and that an average electric car will cover 15,000km per year (Ove Arup and Partners, 1999). A private car occupancy rate of 1.2 people per car is assumed (National Travel Survey, 1992/94).

It is assumed that private car drivers at BedZED will reduce their annual mileage by 20% compared to the average. Of this 20% reduction in mileage, 17% will be transferred to walking or cycling and 83% to public transport (National Travel Survey, 1992/94).

Pool cars are assumed to cover the average annual mileages for fossil fuel and electric cars. Early indications from the Edinburgh City Car Club run by Budget suggest that annual mileages may be lower than this. The average rental duration for City Car Club vehicles is currently 2.8 hours with an average journey length of 23 miles.

It is assumed that each car in the car pool replaces 4 private cars (Budget Rent-a-Car, 1999).

The efficiency achieved by each mode of transport is assumed to be 1.7km / kWh - fossil fuel car, 2.5km / kWh - public transport, (Wood, 1995), 6.2km / kWh - electric car (Ove Arup and Partners, 1999). The energy consumed per km for walking and cycling is assumed to be zero as the energy expended is human rather than fossil fuel or electricity.

The rate of car ownership on a conventional development is assumed to be the London Borough of Sutton average of 0.44 cars per person (London Borough of Sutton, 1998).

The scenarios for years 1, 5 and 10 are based around the addition of 5 vehicles per year to the car pool and a shift over time from fossil fuel to electric vehicles. These developments are thought to be the likely outcome of the implementation of the Green Transport Plan.

The PV panels will produce enough electricity to power 40 electric vehicles. The predicted scenario for year 10 shows the full 40 electric vehicles on the site. This may appear an optimistic prediction given the current status of electric vehicles in the UK. However, BedZED is a forward looking development which aims to demonstrate how real steps towards reducing fossil fuel consumption and air pollution can be taken. As the London Borough of Sutton runs a fleet of electric vehicles, the local electric vehicle infrastructure is further advanced than in many areas. A free, public electric vehicle charging point is already available in a town centre car park.

6. BedZED GREEN TRANSPORT PLAN

6.1 *Introduction*

BedZED – the Beddington Zero Energy Development – is an environmentally-friendly, energy efficient mix of housing and workspace to be built on the land east of London Road in Hackbridge, Sutton. BedZED will be an affordable, attractive and viable example of sustainable urban living.

The BedZED scheme includes a Green Transport Plan that will make it easy and possible for people living or working at BedZED to reduce their car use and car ownership, without sacrificing mobility, flexibility or freedom. As set out in the BedZED scheme specification incorporated in the land purchase contract, this Green Transport Plan aims to reduce private fossil fuel car use miles by 50%, as compared with typical mileage.

The resulting, relatively car-free environment at BedZED will be safer for children, pedestrians and cyclists, and residents and workers will benefit from lower levels of air and noise pollution.

To formalise the commitment to minimising the environmental impact of travel by BedZED residents, the Peabody Trust will enter into a legally binding agreement with the London Borough of Sutton. This document outlines the BedZED Green Transport Plan that will form the basis of this agreement.

The 1998 Government Transport White Paper, 'A new deal for transport: better for everyone', identified Green Transport Plans as a valuable tool for businesses in reducing the environmental impact of travel to work and business travel. The BedZED Green Transport Plan will extend this concept to offer an integrated package of travel options to BedZED residents and workers. It incorporates current best practice in green transport planning including the green transport measures recommended in the DETR advisory document 'Preparing your organisation for transport in the future: The benefits of green transport plans'.

BioRegional Development Group has conducted a detailed survey of the travel patterns of 90 current Hackbridge households. The information gathered in the survey is summarised in the BioRegional document of April 1999, Transport Survey Results and has been used to inform this Green Transport Plan.

6.2 *Aims of the BedZED Green Transport Plan*

The BedZED Green Transport Plan aims to reduce car use and car ownership at BedZED by:

- reducing the need to travel
- promoting public transport
- offering alternatives to private car travel

It is intended that all facilities should be in place when the site opens and users move in.

6.3 *Reducing the need to travel*

6.3.1 Mixed use development

Alongside residential units, BedZED will offer workspace for some 125 employees. Some residents will have the opportunity to live and work on site, either in the workspace or from home, thus reducing commuting traffic.

- In order to encourage residents to pursue a live / work arrangement, BedZED will be specially designed for easy installation of ISDN links throughout the development and tele-suites and tele-cottaging facilities in workspace units.

6.3.2 Internet shopping

The most car-dependent activity in the Hackbridge area is currently shopping[2]. Initiatives to reduce shopping-related car journeys are therefore a high priority.

- BedZED residents will be able to place orders with local supermarkets either from home or via a central internet access point, provided by the Peabody Trust. This is aimed at reducing shopping trips by car.
  Target: 20% of BedZED households to be using supermarket delivery services one year after BedZED opens
- Rather than having each of these individual orders delivered separately, Peabody Trust will seek to negotiate regular deliveries of all BedZED orders. This will minimise mileage by supermarket delivery vehicles.

6.3.3 On-site facilities

Incorporating a number of facilities including into the development will reduce travel not only for BedZED residents, but also for Beddington Corner residents who currently travel further afield for these facilities[2].

- BedZED will include buildings and infrastructure to accommodate a shop, café, childcare facility and a Healthy Living Centre. These will be available for facility providers when BedZED opens.
- Peabody Trust intends to establish a BedZED grocery shop within one year of BedZED opening, stocking everyday supplies including fresh organic produce.
- In partnership with the Northern Wards Healthy Living Taskforce and local health care providers, Peabody Trust will, subject to funding and management arrangements, establish a Healthy Living Centre at BedZED within a year of BedZED opening.
- In partnership with the London Borough of Sutton, Peabody Trust will, subject to funding and satisfactory management arrangements, establish a childcare facility at BedZED within one year of BedZED opening.

6.4 *Promoting public transport*

One of the barriers to public transport use in the Hackbridge area is a perceived lack of information about the services available[2].

- Peabody Trust will provide details of bus, train, coach and tram links that serve the development to BedZED residents and workers. These details will be updated as services change. In addition, this information will be displayed at central points.
- Peabody Trust will negotiate with public transport companies, seeking to obtain discounts for bulk purchase of travel cards for BedZED residents and workers.

A number of current Hackbridge residents do not use the train, as they perceive that the distance to Mitcham Junction station is too far to walk[2].

- Subject to sufficient demand, Peabody Trust will look to provide a people carrier service to Mitcham Junction station at peak times.

6.4.1 Sutton Community Transport

- On-going monitoring of transport patterns of BedZED users may identify gaps in transport provision. Peabody Trust will work with Sutton Community Transport to provide services that meet these needs.

6.5 Offering alternatives to private car travel

Target: Car ownership of BedZED residents will not exceed an average of one car per household at any time.

6.5.1 Cycling

45.5% of all journeys in Sutton are between 1km and 5km long, yet only 2% of these journeys are made by cycle[3]. Increasing the proportion of short journeys made by cycle is therefore a key component of the BedZED Green Transport Plan.

6.5.1.1 Cycle storage provision

Cycling is a healthy, cheap and flexible mode of transport. However, the lack of convenient, secure cycle storage, leaving cycles open to theft, vandalism and the weather can discourage would be cyclists.

- Peabody Trust will demonstrate best practice in cycle storage provision at BedZED.
- Peabody Trust will provide secure, ground floor cycle storage for residents at the rate of 1 space per flat, 2 spaces per maisonette and 3 spaces per townhouse (based on guidelines taken from London Borough of Sutton UDP Review and the National Cycling Strategy).
- In addition, Peabody Trust will provide 30 outdoor lockable cycle spaces for BedZED workers and visitors (based on National Cycling Strategy guidelines).

6.5.1.2 Workspace shower facilities

Employees can be discouraged from cycling to work if appropriate facilities for showering and changing out of cycling clothes are not available[1].

- Workspaces at BedZED will include showering facilities.

6.5.1.3 On-site cycle repair facility

- Peabody Trust will seek to ensure the provision of a permanent or visiting cycle repair service at BedZED or discounted services at a local cycle shop.

6.5.1.4 Links to existing cycle network

- Peabody Trust will seek to establish links from BedZED to existing cycle routes.
- Subject to negotiations with Railtrack, Peabody Trust will seek to establish a link across the adjacent railway bridge, into the new north - south cycle route.
- Peabody Trust will open discussions with Railtrack and landowners by February 2000. Peabody Trust will assess progress in February 2001 and, if necessary, discuss alternative improvements to cycle access with London Borough of Sutton.

6.5.2 Car pool

Many journeys can be undertaken by foot, cycle or public transport but there are some journeys for which a car is the only real option. People buy cars for 'mobility insurance' and then use them for most journeys because of convenience. Having paid for the car's fixed costs, it makes financial sense to use the car for as many journeys as possible.

At BedZED, a car pool will offer 'mobility insurance' without the fixed costs. Users pay by the hour. This will make it possible for people to walk, cycle and use public transport most of the time but still have access to a car for those journeys that need one.

Car pools are already successfully operating in a number of European countries. For instance, the 'Mobility' scheme in Switzerland has 18,000 members sharing 800 vehicles throughout the country, whilst Berlin's 'Stattauto' company has 5,000 members sharing 150 vehicles. A number of schemes have recently been launched in the UK, including Edinburgh's 'City Car Club' run by Budget Car and Van Rental.

Car pools offer users a number of advantages over private car ownership. The experience of European car pools suggests that car pool members with an annual mileage of 7 - 8,000 miles can save up to £1500 a year on their motoring costs. In addition, car pool members benefit from access to a range of vehicles, from small cars, to people carriers to vans, at short notice. This gives car pool members improved flexibility over car owners who only have immediate access to one type of vehicle.

- Acting as facilitators, Peabody Trust will endeavour to establish a car pool, 'ZED Cars', at BedZED, offering both fossil fuel and electric vehicles, including a van and a people carrier, within one year of BedZED opening.
  Target: 25% of potential car owners at BedZED to have joined the car pool two years after 'ZED Cars' opens
- In the event of the car pool being fully booked, the car pool will offer a minicab ordering service as an alternative.

6.5.3 Promoting electric vehicles

Electric vehicles, which produce minimal air and noise pollution, are ideal for short urban journeys.

- Peabody Trust will, subject to receipt of matching EU THERMIE funding, equip BedZED with roof-mounted photo-voltaic solar panels to provide a renewable, carbon-neutral source of electricity sufficient to power 40 electric vehicles.
- Subject to funding, BedZED car pool will initially include two electric vehicles. Peabody Trust intends to add further electric vehicles as the service grows.
- Peabody Trust will equip five parking bays at BedZED with recharging points for electric vehicles.

A £2,000 subsidy per electric vehicle is available from 'Powershift', a scheme run by the Energy Saving Trust.

- Peabody Trust will encourage BedZED residents and workers to consider private ownership of electric vehicles.
  Target: 10 BedZED residents will exchange their fossil fuel vehicles for electric vehicles within one year of BedZED opening

Electric vehicles have a range of approximately 60 miles. For longer journeys, BedZED electric vehicle owners can use fossil fuel vehicles from the car pool.

6.6 Parking Provision

Standard parking requirements for the BedZED scheme, based on the Sutton UDP (1999) would be a minimum of 121 residential spaces and a maximum of 79 non-residential spaces. However, the calculations below show that, due to the transport initiatives described and the likely nature of BedZED residents, this number can be significantly reduced.

Except for car pool spaces, all parking spaces at BedZED will be non-allocated, therefore residential and non-residential spaces can double up.

6.6.1 Residential parking

Surveys suggest that car ownership levels amongst BedZED residents will be lower than average levels in Sutton for a number of reasons.

At least 15 homes at BedZED will be allocated for social housing. Car ownership amongst social housing residents is 50% lower than the average levels in Sutton[4]. The standard allocation of 19.5 spaces for the social housing units can therefore be reduced by 50% to 10 spaces.

BioRegional has conducted a survey of 30 households that include a person working for Sutton-based environmental organisations. Car ownership amongst these 'environmentally aware' households is 50% lower than the Sutton average.
It is conservatively assumed that car ownership amongst non-social households at BedZED will be at least 25% below the Sutton average, due to 'environmental awareness'. Therefore, non-social residential parking provision could be reduced from 101.5 to 76 spaces.

According to Budget Car and Van Rental, who operate a car pool in Edinburgh, each pool car replaces the need for 4 to 6 private cars. Therefore, if just 1 in 12 of all potential car owners at BedZED give up car ownership and use the car pool, then total residential parking provision can be further reduced to 79 spaces.

The car pool will initially require 5 spaces, taking the parking requirement to 84 spaces.

- Peabody Trust will offer 84 parking spaces at BedZED.

In order to estimate the number of residents' cars that will be out during the day, parked cars have been counted in 3 residential streets in the London Borough of Sutton both during office hours and late at night. The results below are expressed as a % of cars absent during the day, compared with night time:

Foxglove Way / Poppy Close	38%
Bloxworth Close	56%
St James Road	39%

If just 36% of BedZED residents' cars go out during the day, this would release space for 30 non-residential cars.

6.6.2 Non-residential parking

The mixed use development means that some of the workers will live on site and will therefore not bring additional cars. By encouraging cyclists, use of public transport and green transport plans for businesses, we aim for car use amongst businesses to be reduced by 50%. Businesses will have access to the car pool, so staff will not have to bring in their own cars for short business trips. Each pool car replaces the need for 4-6 private cars. All facilities such as the café, the shop and the healthy living centre will be targeted at serving local residents within walking distance.

Taking these factors into account, the following estimates have been made for non-residential parking space provision.

Workspace	14
Healthy living centre	10
Childcare facility	2
Café / shop	2
Clubhouse / sports facility	2
Total	30

If our policies are more successful than anticipated, it is possible that residents who own cars will not use them much and therefore, will not release spaces for office workers during the day. On the other hand, if our policies are successful, numbers of workers' cars will also be very low. This balance will need to be monitored and results can be reported to the BedZED Transport Forum (see 6.9 below).

6.7 Parking Control

- Residents and workers will be able to purchase BedZED annual parking permits.
- The number of residential permits issued will be limited to the number of spaces available.
- Visitors to the site will park free for periods of up to 2 hours. If parking for over 2 hours, visitors will purchase pre-paid parking permits from the BedZED shop or café. Businesses can make these permits available to their visitors.
- These parking restrictions will be controlled by a Parking Enforcement Contractor.
- Periodic assessments will be undertaken of the parking habits of BedZED residents in surrounding streets.
- Revenue from the sale of car parking permits will be used to support facilities at BedZED.

6.8 An Integrated Solution

- As facilitators, Peabody Trust will establish a BedZED Travel Club to administer the package of travel options described above and to negotiate travel discounts for residents and workers.

6.9 Strategy Development

- Peabody Trust will monitor this Green Transport Plan on an annual basis in conjunction with a forum consisting of BedZED residents, members of the surrounding community, representatives of Peabody Trust and Council members and officers.
- Peabody Trust will review this Green Transport Plan every five years, in consultation with BedZED residents and workers, to ensure services are meeting their transport needs.
- Two years after BedZED opens, Peabody Trust will produce dissemination materials to promote the results of this Green Transport Plan to a wider audience.

[1] Preparing your organisation for transport in the future: The benefits of green transport plans, DETR, 1999
[2] Beddington Zero Energy Development Transport Survey Results, BioRegional Development Group, 1999
[3] London Borough of Sutton Sustainable Transport Strategy, 1998
[4] MORI poll for Peabody Trust, 1997

7. CONSUMER BEHAVIOUR TOWARDS ENERGY EFFICIENT HOUSING AND TRANSPORT

7.1 Introduction

In 1997 / 98, María José Carrasco Sánchez, an MA student at Kingston Business School, carried out a study of 'Consumer behaviour towards environmentally friendly houses using the theory of planned behaviour'. The questionnaire which formed the basis of this research was designed in conjunction with BioRegional.

BioRegional's aim in participating in this study was to collect data on consumer perceptions of environmentally friendly houses. This information will be used to inform the marketing strategy for BedZED.

The questionnaires included a number of questions relating to the BedZED energy strategy, the responses to which were analysed for this report.

7.2 Method

Data for the study was collected via a questionnaire distributed to a random sample of 500 addresses within the M25 and inserted in 500 copies of the magazine 'Permaculture'.

The following questions in the questionnaire related to the BedZED energy strategy:

1. Would you be willing to buy an environmentally friendly house which saves you money in the long term?

2. Assuming that you are considering buying an environmentally friendly house, how would you rate the importance of:
   a. energy efficiency?
   b. use of energy from renewable sources?

3. How would you rate the importance of living in an area with access to public transport?

4. Would you consider getting rid of one or more of your cars if a car pooling / sharing scheme was available?

5. If there was rented office workspace within the development would you use it?

Respondents were asked to answer each question on a 7 point scale indicating e.g. how they rated the importance of a certain feature in a house or how likely they were to use a certain facility in the development.

7.3 Results

In total, 189 responses to the questionnaire were received, 49 responses from households within the M25 and 140 responses from readers of 'Permaculture' magazine.

1. Would you be willing to buy an environmentally friendly house which saves you money in the long term?

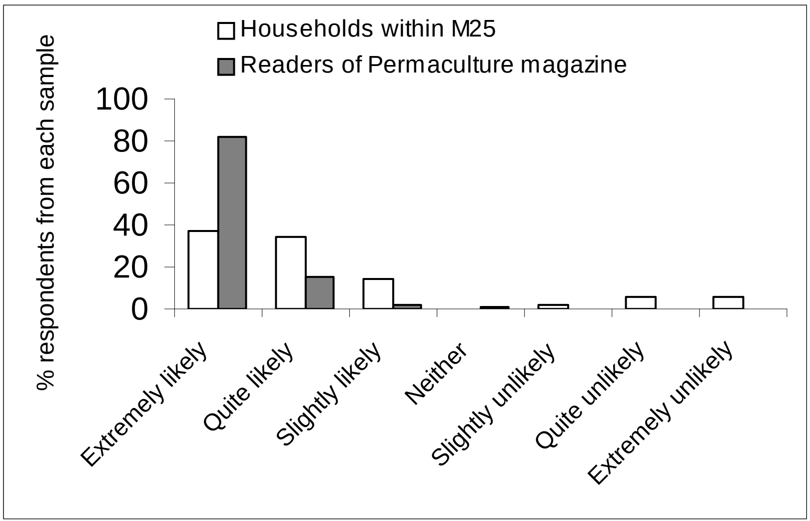


Fig. 1: Likelihood that respondents would buy an environmentally friendly house that would save them money in the long term

From fig. 1, it can be seen that on average both samples would be willing to buy an environmentally friendly house that saves them money in the long term. Households within the M25 are slightly less enthusiastic about this concept.

2. Assuming that you are considering buying an environmentally friendly house, how would you rate the importance of:
   a. energy efficiency?
   b. use of energy from renewable sources?

The approval ratings for each of these features were analysed in comparison to approval ratings for five other features: water recycling, waste recycling, use of local building materials, use of natural building materials and use of a non green field site.

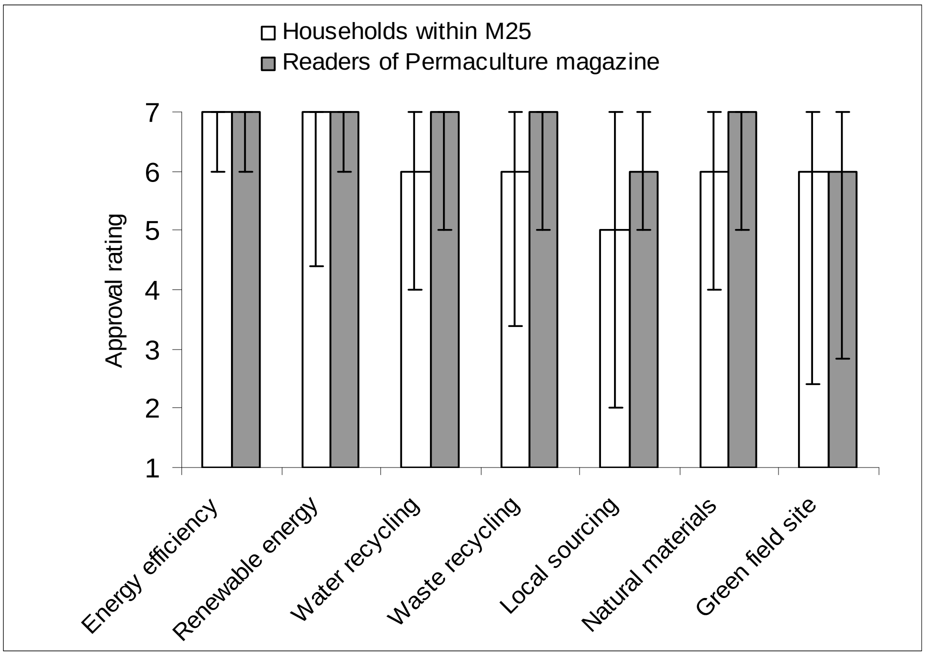


Fig. 2:

- Median approval ratings for various features of environmentally friendly housing. The median is an estimate of the average approval rating for each feature. For instance, although, on average, readers of Permaculture magazine think that water recycling is very important; households within the M25 only rate water recycling as important.
- The vertical lines on each bar of the chart are error bars. These error bars show the range of approval ratings for each feature, leaving out the top and bottom 5% of respondents. This is known as a 90% confidence interval. The longer the error bar, the greater the range of approval ratings for a feature. For example, the ratings for local sourcing by households within the M25 range from very important to unimportant, whereas the same sample rates energy efficiency no lower than important.
- Approval ratings represent 1 - very unimportant; 2 - unimportant; 3 - quite unimportant; 4 - neutral; 5 - quite important; 6 - important; 7 - very important.

Within both samples, there was statistically significant variation between levels of approval for different features of an environmentally-friendly house (Statistical test results: Kruskal-Wallis tests: Households within M25 - $\chi^2 = 61$, df = 6, $p < 0.0001$; Readers of Permaculture magazine - $\chi^2 = 126$, df = 6, $p < 0.0001$). This result shows that it can be statistically proven that the people questioned rate some features of environmentally housing more highly than others.

For both samples, the median approval ratings for all features were at the positive end of the approval scale i.e. quite important or above.

The patterns of approval are similar for the two samples but overall levels of approval are consistently higher in readers of Permaculture magazine. This group give energy efficiency and renewable energy the greatest importance. Water and waste recycling and the sourcing of local and natural materials are ranked only slightly lower. Only for greenfield site considerations is there a minority which attaches little importance to this issue.

Households within the M25 also showed strong approval for energy considerations. However, for all other features there were minorities who ranked importance as neutral or below. The lowest approval ratings were given to waste recycling, greenfield sites and local sourcing. This group ranked local sourcing as the least important feature, in contrast to Permaculture readers, who attached relatively high importance to this issue.

3. How would you rate the importance of living in an area with access to public transport?

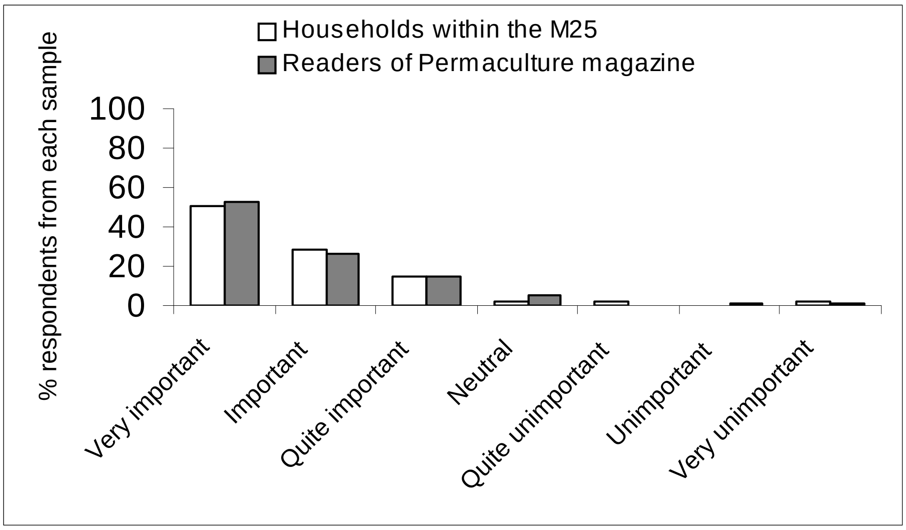


Fig. 3: Importance attached to access to public transport by respondents

From fig. 3, it can be seen that access to public transport is given high importance regardless of sample.

4. Would you consider getting rid of one of more of your cars if a car pooling / sharing scheme was available?

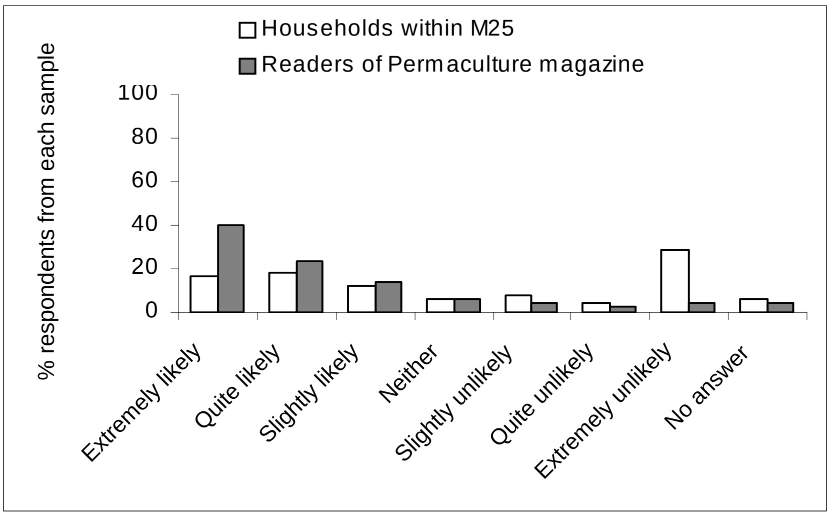


Fig. 4: Likelihood that respondents would get rid of one or more cars if a car pooling scheme was available

From fig. 4, it can be seen that the majority of Permaculture readers would consider getting rid of one or more of their cars if a car pooling scheme was available. Amongst households within the M25, opinion is split on this issue. In this group, most of those who were unlikely to take advantage of a car pooling scheme felt very strongly that they would not give up their car.

5. If there was rented office workspace within the development would you use it?

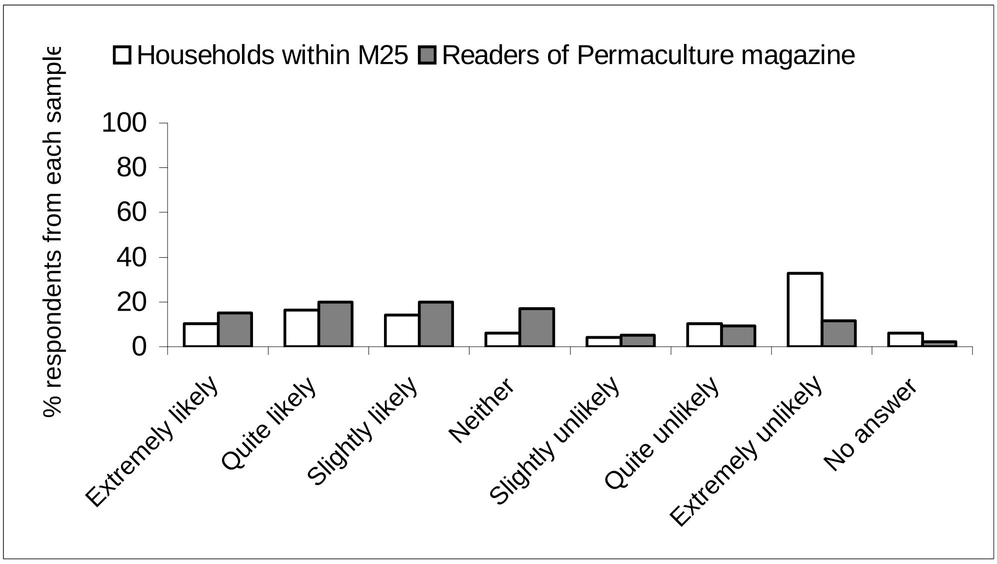


Fig. 5: Likelihood that respondents would use rented office workspace on the development

From fig. 5, it can be seen that, in both samples, the option of renting office workspace received a broad spread of responses. There are many people who will have no choice regarding where they work. This option will only be open to those who regularly work from home e.g. the self-employed. Permaculture readers are slightly more likely to take advantage of this facility.

7.4 *Conclusions*

Across both samples, responses to the environmentally friendly features of the houses and development are largely positive suggesting that consumers would respond to marketing of these features.

As would be expected, readers of Permaculture magazine are more enthusiastic about the environmentally friendly features than randomly selected households within the M25. This suggests that environmentally motivated people are likely to be more readily attracted to BedZED and the features and facilities it offers.

Energy efficiency and renewable energy were identified as the most popular features. Marketing of the development should therefore stress these features.

Respondents in both samples were interested in buying a house that saved money in the long term, therefore marketing should emphasise any potential long term savings offered by energy efficient buildings.

It is interesting that respondents rated the provision of recycling facilities as only as important as lower profile environmental issues such as local sourcing of construction materials and developing brown field sites. Many local authorities now provide kerbside recycling schemes and achieve high participation rates. It is possible that respondents felt that there is already good provision for recycling therefore further facilities are not so important.

Amongst households within the M25 there is a significant minority who consider themselves very unlikely to relinquish their cars even when offered a pool car as an alternative. As the car pool is a relatively new concept in the UK this may be due to a lack of information about the services a car pool offers. However, many people do lead a car based lifestyle, therefore giving up a car is seen as a large step to take. Readers of Permaculture magazine, who are likely to be more environmentally aware appear more comfortable in taking this step. In order to persuade people to give up their cars we need to offer a convenient package of options which residents are confident will not restrict their mobility. This should be complemented by examples of the financial benefits of moving over to a pool car.

55% of Permaculture readers and 40% of households within the M25 expressed an interest in renting office space in the development. A package offering a combination of purchasing / renting a house and renting office space could be offered to encourage this option. We could also develop 'telesuites' at BedZED, enabling residents whose work is not tied to a specific location to work from a BedZED telesuite rather travelling to the company office each day.

8. ANNUAL SAVINGS ON ENERGY BILLS FOR A BEDZED HOME COMPARED WITH A CONVENTIONAL HOME

Energy efficient housing and transport offer significant benefits to the environment in terms of reduced CO_2 emissions. In addition, BedZED residents will benefit from lower household bills.

8.1 Lighting and appliances

	Annual household energy use (kWh)
3 bedroom BedZED maisonette [1]	1663
Typical 3 bedroom, semi-detached house built to 1995 building regulations [2]	3831

[1] Chapter 3, Energy Analysis
Each energy consumption scenario is based on a combination of appliance performance and occupier usage patterns.
[2] DETR, 1998

Table 1: Annual energy use (kWh) for lighting and appliances in a 3 bedroom BedZED maisonette and a typical 3 bedroom, semi-detached house built to 1995 building regulations

	Cost of annual energy use (£)
3 bedroom BedZED maisonette	155 [3]
Typical 3 bedroom, semi-detached house built to 1995 building regulations	290 [2]

[2] Southern Electricity Standard Domestic Electricity Tariff: standing charge £9.39 per quarter, unit rate 6.22p per kWh
[3] Southern Electricity Acorn tariff (green tariff): standing charge £9.39 per quarter, unit rate 6.53p per kWh

Table 2: Annual cost of energy use for lighting and appliances in a 3 bedroom BedZED maisonette (standard and green tariffs) and a typical 3 bedroom, semi-detached house built to 1995 building regulations

Therefore, a household living in a 3 bedroom BedZED maisonette will save £134 per year on electricity costs for lighting and appliances compared with a household living in a typical 3 bedroom house built to 1995 building regulations. These savings are despite the fact that BedZED households will pay a premium rate for their green electricity.

The majority of electricity at BedZED will be supplied from the CHP. At times of peak demand, energy will be drawn in from the grid on a green tariff. These calculations assume that the unit rate for electricity from the CHP will be similar to the green tariff rates offered by regional electricity companies.

8.2 Space and water heating

	Annual equivalent heat demand (kWh) for space and water heating
3 bedroom BedZED maisonette [3]	4380
Typical 3 bedroom, semi-detached house built to 1995 building regulations [1]	12474

[1] Chapter 3, Energy Analysis
[3] Chapter 4, Predicted Energy Consumption, Ove Arup and Partners, 1999

Table 3: Annual equivalent heat demand (kWh) for space and hot water heating in a 3 bedroom BedZED maisonette and a typical 3 bedroom, semi-detached house built to 1995 building regulations

	Annual cost of space and hot water heating (£)
3 bedroom BedZED maisonette	95 [4]
Typical 3 bedroom, semi-detached house built to 1995 building regulations	201 [4]

[4] Based on SEEBOARD Standard Credit Domestic Gas Tariff (Dual Fuel customers): Band A (first 1465 units per quarter) 2.167p / kWh, Band B (all further units) 1.127p / kWh. It is assumed that the first 5860 kWh per year is charged at the Band A rate.

Table 4: Annual costs of space and hot water heating for a 3 bedroom BedZED maisonette (standard gas tariff and green electricity tariff) and a typical 3 bedroom, semi-detached house built to 1995 building regulations

Therefore, a BedZED household will save £106 per year on space and water heating compared to a household living in an equivalent house built to 1995 building regulations.

A household living in a 3 bedroom BedZED maisonette will therefore save up to £240 per year on household energy costs compared to a household living in an equivalent house built to 1995 building regulations.

These calculations assume that the heat energy generated by the BedZED CHP will be sold at a similar unit rate to standard gas tariffs.

It should be noted that in order to ensure that the BedZED CHP is financially viable, it may be necessary to charge higher unit rates for both heat and electricity.

9. PRIVATE CAR VERSUS POOL CAR: A COST COMPARISON

Residents at BedZED will be encouraged to give up one or more cars and join the car pool. With rent by the hour flexibility, a car pool offers members 'mobility insurance' without the fixed costs of owning a car. Once you have paid for the overheads of owning a car, it makes sense to use it for most journeys. However, as a car pool member you only pay for the car when you use it, therefore there is a greater incentive to walk, cycle and use public transport.

Based on the experience of members of their 'City Car Club' car pool in Edinburgh, Budget Car and Van Rental suggest that a member with an annual mileage of 11,000 to 13,000km could save up to £1500 per year on their motoring costs.

The financial benefits of using a pool car rather than a private car will be even greater at BedZED where the annual cost of parking will be £500.

Car ownership

Item	*Cost*
Depreciation	£685
Road tax	£150
MoT test fee	£28
Road rescue service	£70
Insurance	£250
Annual BedZED parking permit fee	£500
Net loss of interest on cash used to buy car	£104
Fuel	£717
Tyres, servicing and maintenance	£250
Total annual cost	**£2,754**

Table 1: The annual costs of running a car, assuming an annual mileage of 16,000km at 40 miles per gallon (The Car Club Kit, 1998)

Alternatives to car ownership

Item	*Cost*
Running a bike	
▪ Capital cost £300 depreciating over 3 years	£100
▪ 2 inner tubes, lubricant, brake blocks	£20
▪ Annual service	£50
5 local trips by bus/train per week @ £2 per trip	£520
2 minicab journeys per week @ £5 per trip	£520
1 day car hire per week @ £28.95 per day	£1,505.40
Total Annual Cost	£2,715.40

Table 2: The annual travel that can be achieved for the same price as running a car

Tables 1 and 2 demonstrate that a BedZED resident giving up a private car could run a well serviced bike and travel regularly by public transport, taxi and hire car for the same price as running a private car.

Car pool rates will be lower than commercial car hire firms due to internalised costs and transfer payments from parking revenue. £1,505.40 will therefore cover a greater number of days of car pool car use.

The costs outlined in table 1 are at the cheaper end of the scale for running a car. Residents giving up a larger, newer car would benefit even more.

This calculation does not take into account the commuting costs for BedZED residents who work in London. It is assumed that residents will commute into London by train regardless of whether they own a car or not, as the nearby Hackbridge station offers regular, direct trains into London. The cost of an annual season ticket from Hackbridge to London is £1,040.

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